POWER

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GO EASY

By BERTON BRALEY

Fireman, spare that coal,
Oh have a heart, somehow;
It cost us quite a roll,
So please don't waste it now!

Don't heap it on the grate
To clinker, cake and smoke;
Pause, ponder, hesitate,
Or you will have us broke!

Fireman, spare that coal,
Don't waste it all the while;
You've made an awful hole
Already in that pile.

If you will use your brain,
Intelligence and such,
You will not need to strain
Your back and arms so much.

True, we have coal to burn,
But not to burn for fun;
So we would have you learn
How firing should be done—

To get the greatest heat,
Yet save our precious roll,
And therefore we repeat,
"Fireman, spare that coal!"

Sparrows Point Gas-Engine Plant

By Julian C. Smallwood*

SYNOPSIS—At the Sparrows Point, Md., works of the Bethlehem Steel Co., the present air-compressor plant derives its power from gas- and steam-driven engines. Because of the cheaper power costs, the steam-driven units are to be replaced by gas engines and the steam-driven rolls are to be replaced by electric motor-driven rolls, current for which will be generated by gas-engine generator sets. A feature of the plant is that the gas washing is practically accomplished under one roof with the power units, a single force of operators only being required for the two purposes.

Sparrows Point is a narrow strip of land projecting irregularly into Baltimore Harbor, about ten miles from that city. It is the location of the old Maryland Steel Co., now a part of the Bethlehem concern. Here big things are being done in the steel industry and bigger things are planned for, in an engulfing plan of enlargement. Of the magnitude of the enterprise one may judge by considering but one aspect of it, the generation of power, which it is the purpose of this article to present.

At the present time the Sparrows Point plant derives its power for blowing the furnaces in part from gas-engine-driven air compressors and in part from steam-driven ones. The steam and gas engines are located in separate power houses, which are supplied with fuel from one source, blast-furnace gas from four furnaces. With this equipment comparisons of the costs of blowing with gas-fired boilers against internal-combustion engines can readily be made, and it has been found that the latter are very much cheaper. For this reason it has been decided to replace the steam units by the more economical gas engines and, further, to replace the steam by electric motor-driven rolls, current for which will be generated by power from gas engines of the mammoth type developed by the Bethlehem Steel Co. and designed by Arthur West.

Fig. 2 is a plan of the future power plant, now started, including that in present successful operation. The units shown with dotted parts indicate the provision made for

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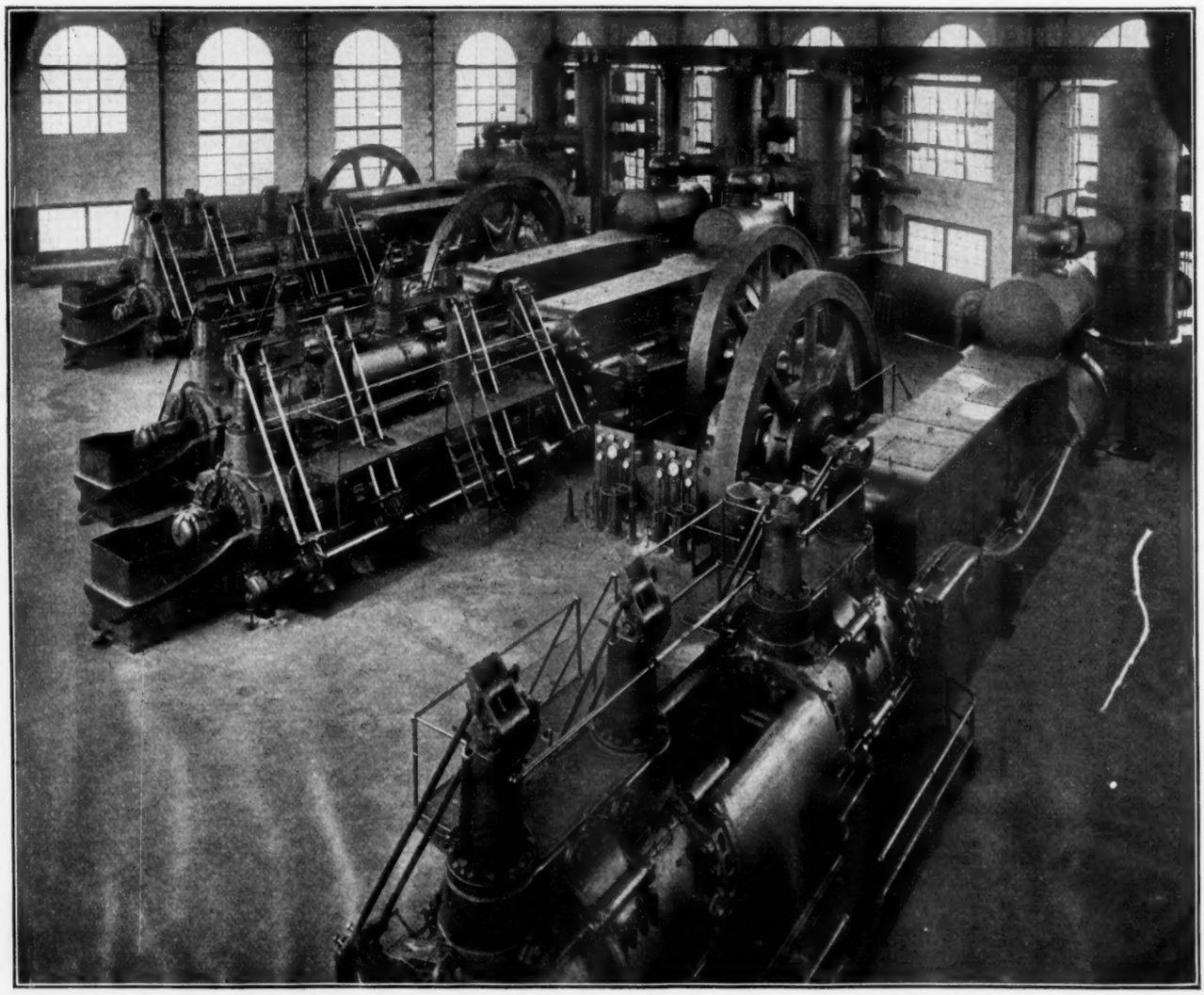

FIG. 1. GENERAL VIEW OF ENGINE ROOM. THESE 2000-HP. UNITS ARE 84 FT. 6 IN. LONG

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still further expansion. The immediate plans are for the three rows of engines shown in full lines. There will be ten 4000-kw. gas-electric twin-tandem units (row next to the top). Maximum capacity at 82.3 r.p.m. The tandem cylinders will be 47-in. bore and 60-in. stroke. The blowing engines (shown in the two lower rows) will consist of the present engines (indicated by the heavy border lines) and 14 additional units of the same type, but larger than the present blowers by 2 in. on the gas-cylinder diameter and 5 in. on the air cylinder. These units have two gas cylinders of the same size arranged tandem with one air cylinder, the new engines being 47x85x60 in., capable of delivering between 22,000 and 27,000 cu.ft. of free air per minute. Eight furnaces will supply the fuel for driving 16 blowing engines and 8 gas-electric units, the remainder, three blowing and two gas-electric, being provided as spares. The various items of arrangement, operation, regulation and distribution in the new plant will be practically identical with the old, actual service having proved the excellence of the plans. The following description of the present plant in regard to these items may therefore be taken as illustrative of the new one.

It will be seen, from what follows, that the characteristic feature, aside from the size of the units, is the completeness of the equipment, and this means flexibility and uninterrupted service. For example, there are three sources for the supply of cooling water and three for ignition, and all auxiliaries in the form of pumps, compressors, washers, etc., are in duplicate. Five blowing engines of the type just described are installed in the present power house, shown in Fig. 2 (inclosed within heavy lines). These units are 45x45x80 in. diameters, and 60-in. stroke, rated at 2000 i.hp. each at 70 r.p.m., and each delivers between 20,000 and 25,000 cu.ft. of free air per minute. They furnish all the air to blow two furnaces and half the air to a third. There are four furnaces in all, the balance of the air required being made up by the steam air compressors. Fig. 1 is a general view of the engines.

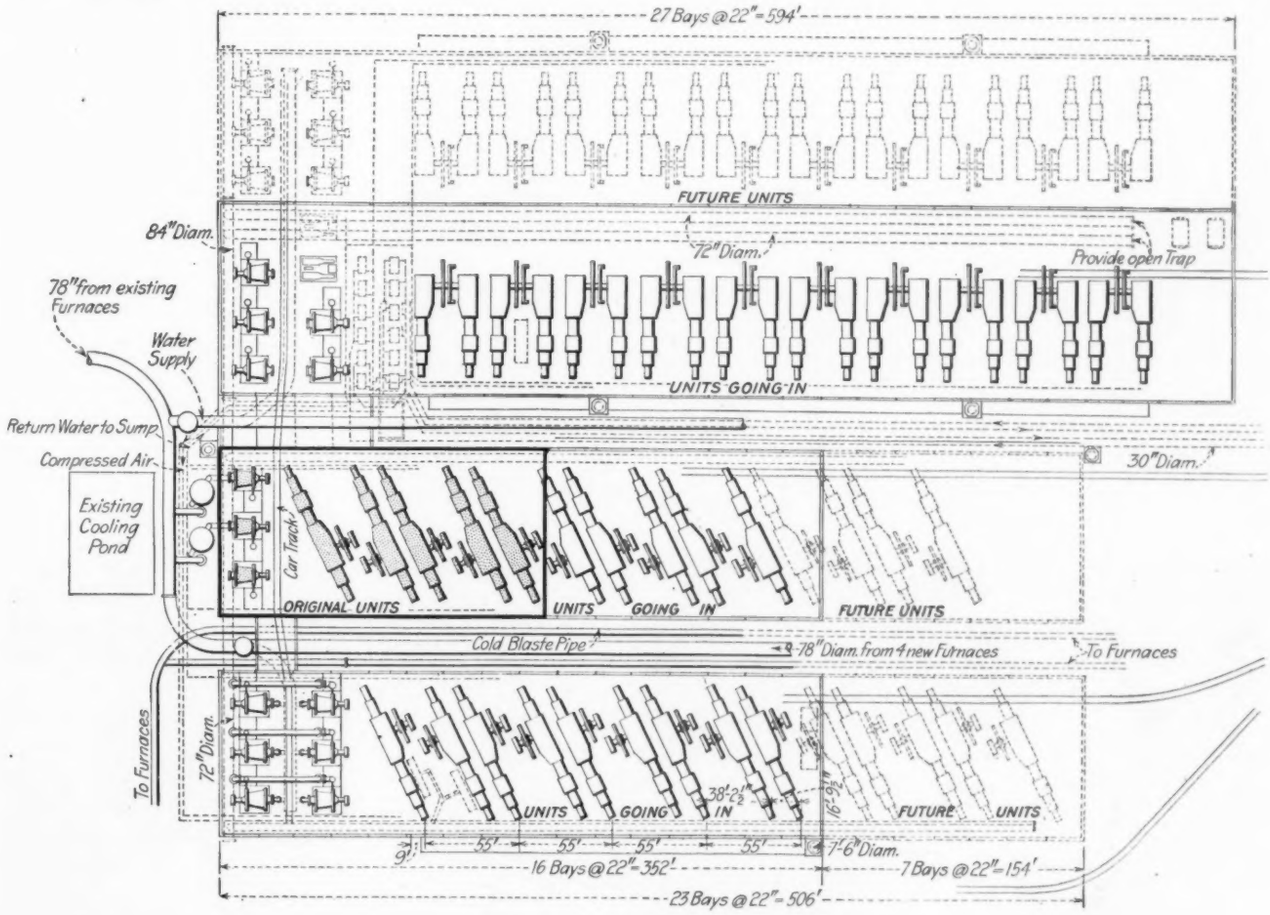


FIG. 2. GENERAL PLAN OF THE NEW PLANT

The present plant is inclosed in solid lines. The Zschocke washers, shown by circles on the left of the present plant, will be placed near the furnaces in the new installation. The blowing units are placed on a slant to economize floor room, this arrangement permitting the flywheels to be staggered

A feature of the plant is that the gas washing is practically accomplished under the one roof with the power units, thus requiring only a single force of operators for the two purposes. It is said that this is the first plant to apply this plan. The gas is led from the furnaces in a 78-in. overhead main (from the left in Fig. 10) to one of the two Zschocke washers (the two towers in the middle of the illustration), the other one of which is used as a spare. Here the gas ascends, is partly washed by a stream of falling water precipitating the dust to the bottom and is cooled from a temperature of about 200 to 75 deg. F. Thence it passes to the interior of the building, where it enters one of the two centrifugal washers through a 36-in. main. In these the gas is mixed intimately with a water spray while passing through revolving vanes driven by the induction motors to be seen in the view of the washers, Fig. 4. After leaving the centrifugal machine, the fine

gas passes through the 36-in. main header (top of Fig 4) and thence to a pipe in the basement running the length of the building and supplying each gas engine from beneath. The washing is all done with salt water drawn from the bay, which is only a few hundred feet distant.

The exhaust pipes are not jacketed, but are cooled by the introduction of salt water, which escapes as steam. The stack shown on the left of Fig. 10 discharges the exhaust gases into the atmosphere.

The engines are cooled by circulating fresh water through their jackets, piston rods, pistons and valves. This fresh water is recovered by cooling in a spray pond shown by Fig. 10. The same view shows a water tower on the extreme right, for emergency purposes. Should

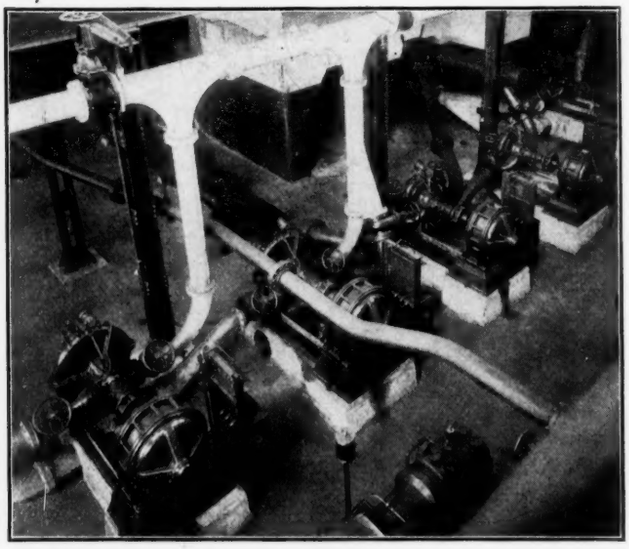


FIG. 3. WATER PUMPS AS SEEN FROM THE ENGINE-ROOM FLOOR

Two pumps on the right, not shown, are for the spray nozzles; the next two are for salt-water washing and cooling, and the two on the left for the jackets. In the foreground is an air compressor cylinder

the electric power fail, thus cutting off the motor-driven auxiliaries supplying the cooling water, this tank contains enough to cool the engines for fifteen minutes, during which time the system could be switched onto steam-driven pumps discharging salt water.

The range of temperature of the jacket water is from 120 to 160 deg. F., and 30 sprays are used to restore it to the lower temperature.

On the engine and washer cooling-water lines there are funnel drips for observing and regulating the supply.

A nice feature of this plant is that the auxiliary room, although in the basement, can be viewed from the engine-room floor (Fig. 3). As before mentioned, each auxiliary is duplicated for breakdown service. The water-pumping units are all of the centrifugal type, directly driven by induction motors. Fresh water is taken by one of these pumps and discharged through the jackets, and thence into the cooling pond. It is then circulated by one of another pair of pumps through the spray nozzles. A third pair is provided for supplying salt water to the Zschocke and Theisen washers and to the exhaust manifolds.

There are also two induction motor-driven two-stage air compressors, delivering into storage tanks. The compressed air thus collected is used for starting the gas engines and throwing the gates on the distribution lines from the gas-engine blowers. These auxiliaries are 14x7x10 in. and discharge at 150 lb. pressure.

Ignition current is furnished by one of a pair of motor-generating sets. Storage batteries are also kept in reserve, should anything happen to the electric power driving the motor generators.

The air delivered to the furnaces is at a pressure between 15 lb. and 22 lb., depending upon furnace conditions. The engine speed can be controlled to meet these conditions through a variable speed-relay governor. Referring to Fig. 8, an air dome is mounted on the air cylinder with an angle-check valve to prevent excessive pressure coming on the cylinder through possible back explosions from the furnace. The air passes from the drum into a vertical distributing tank provided with three outlets and three gate valves. These valves are mechanically thrown by air pressure controlled at the operator's board, which can be seen in Figs. 1 and 9. The three outlet pipes are thus arranged so that any one of three furnaces can be blown by any two of the gas-engine units. Fig. 7 is a view of the pipe lines outside of the building. When starting these engines, a snort valve is used, which bypasses the air back into the basement, thus relieving the engine from load. This valve is also controlled from the operator's board.

Some Construction Details

There are some interesting features of design on both gas and air ends of the engines. For example, the gas cylinders are made of cast steel, for the reason that the necessary thickness of cast iron to resist the tremendous forces is attended by nonuniform temperatures in operation and consequent straining. A good idea may be had of the size of these units, when one looks at Fig. 12, which represents one of the gas pistons and rods. This piston, when subjected to an explosion pressure of 350 lb. per sq.in., must withstand a total load of 500,000 lb. This also suggests the difficulties encountered, and successfully met, throughout the design.

The gas-cylinder valves are operated from an eccentric shaft, Fig. 5. This shaft carries four eccentrics, each of which throws two valves, one for inlet (at the top of the cylinder) and one for exhaust (at the bottom). The valves are of the regulation poppet type, but each inlet-valve cage carries a sleeve mixing valve so designed as to maintain the proportion of gas and air at different governor positions, the governor controlling the amount of mixture by varying the sleeve position. The eccentric shaft also drives the variable-speed relay governor, the cylinder-oil pumps and the air-starting valves.

All air, gas, starting valves for each engine are controlled at one point, the operator's board for that engine. On the backs of these boards are a series of small pilot-light bulbs, one for each make-and-break igniter, proving the current at the sparking points.

The apparatus regulating the pressure of the fuel at each engine is a gasometer. When the pressure rises slightly, the floating upper tank of the gasometer rises and actuates a butterfly valve to throttle the incoming gas and reduce the speed.

Fig. 6 shows some inlet and discharge valves for the air ends. These consist of sheet-metal vanes set in a cage and have a free area equal to 24 per cent. of the piston area. The heads of two of these valves, as set in the cylinder, can be seen at the left.

A recording venturi meter is located in the fine gas main in the basement, and this measures the hourly rate and total fuel consumption, the latter being about 1,000,000 cu.ft. per hour. The gas engines are individually equipped with recording tachometers, speed counters and reducing motions for indicators. The reducing motions are of the wedge and shoe pattern and are transmitted to the indicators by cables amply supported on pulleys. Each operator's board has gages showing the blowing pressure, governor- and cylinder-oil pressure, jacket-water pressure and fuel pressures (by manometers).

On the recording-instrument board, located on the wall back of the washers (see Figs 4 and 11), there are meters for the following: Pressure of salt water to the Zschocke washers, to Theisen washers, to spray nozzles, and fresh water to the tower, also the pressure of the gas entering the Zschocke washers, entering and leaving the Theisen washers, and of the fine gas in the main header. There are also recording thermometers giving the temperatures of the raw and fine gas and the temperature between the washers as well as the jacket-water temperatures before and after cooling the cylinders. These meters enable regulation of the water supply and furnish information upon the condition of the passages during washing in regard to the accumulation of dust.

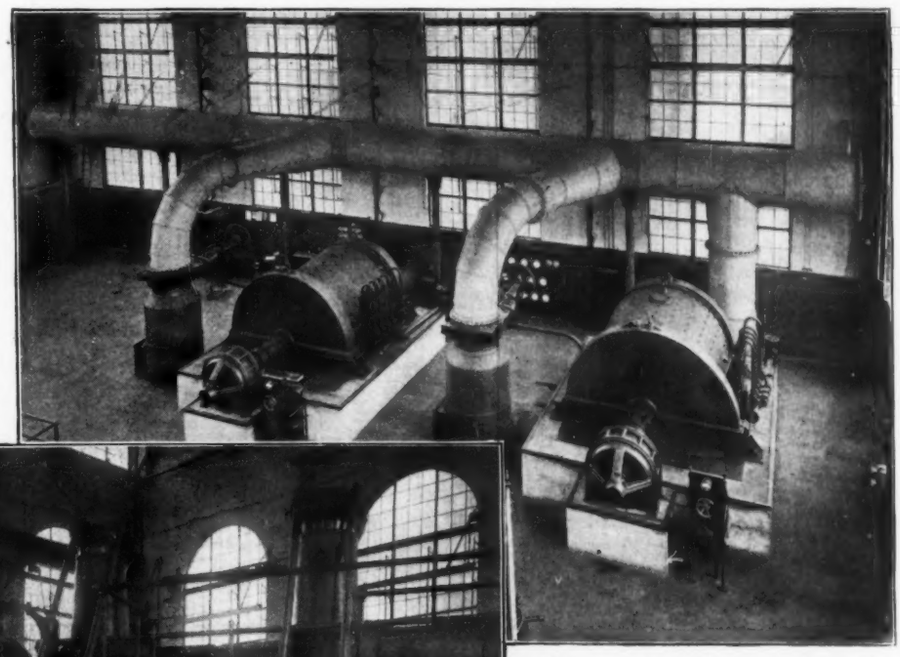


FIG. 4. THE THEISEN CENTRIFUGAL WASHERS

The fine gas rises from these to the header, through the water seal shown at the left of each washer. Room is provided at the left for a third washer to be used in the new installation

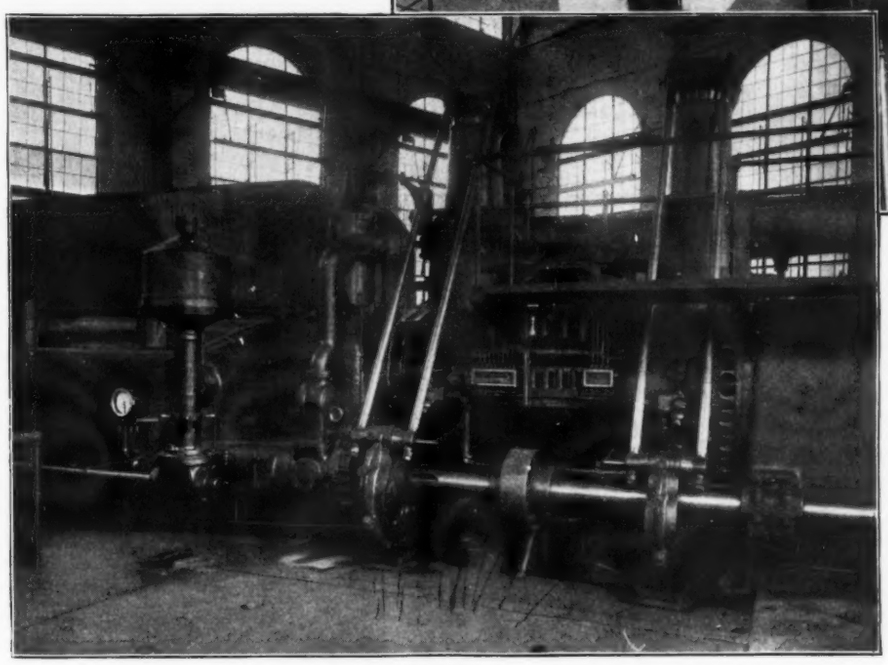


FIG. 5. GAS-ENGINE CYLINDER, SHOWING ECCENTRIC SHAFT

An idea of the endurance and dependableness of these engines may be had when it is said that, for the period of one year, only 321 hours were lost by all five units during night and day operation. One of them has a record of 104 24-hour days of continuous operation, from Jan. 5 to Apr. 19, 1916.

Some remarkable mechanical-efficiency results were quoted to the writer. Although they are higher than any on gas engines that have come to my knowledge before, there is no fault to be found with the carefulness used in testing, so they are presented here at their face value. The average i.hp. of the air end (covering several hours' run) was 1654, and the corresponding i.hp. of the gas cylinders was 1896, giving an over-all efficiency of 87.2 per cent. Allowing 98 per cent. for the mechanical efficiency of the air cylinder (based on previous tests), the mechanical efficiency of the gas engine, based on the brake horsepower, is 89 per cent.

Fig. 13 is a set of indicator diagrams, including a gas-cylinder suction diagram. In this the low back pressure on the exhaust is to be noted—probably due to the draft effort of the stack which receives the exhaust gases. The compression line rises snappily at the beginning of the stroke, and the suction line is good. Notice also, on the air diagram, the high apparent volumetric efficiency. By the use of the venturi meter, tests of fuel and heat consumption are occasionally made. The following figures represent regular operation at about three-quarters capacity, the results being averages of four engines: Fuel consumption, cu.ft. per b.hp.-hr., 97; heat value of the gas, B.t.u. per cu.ft., 105; heat consumption in B.t.u. per b.hp.-hr., 10,190; thermal efficiency, per cent., 25. The combustible elements of the gas are about 30 per cent. CO and 1 per cent. hydrogen.

When comparing these figures with results from other engines, it must be remembered that most published results are taken under the *best* instead of the *usual* operating conditions. The best performance of the Bethlehem Steel Co.'s large gas engines is said to be 9500 B.t.u. per

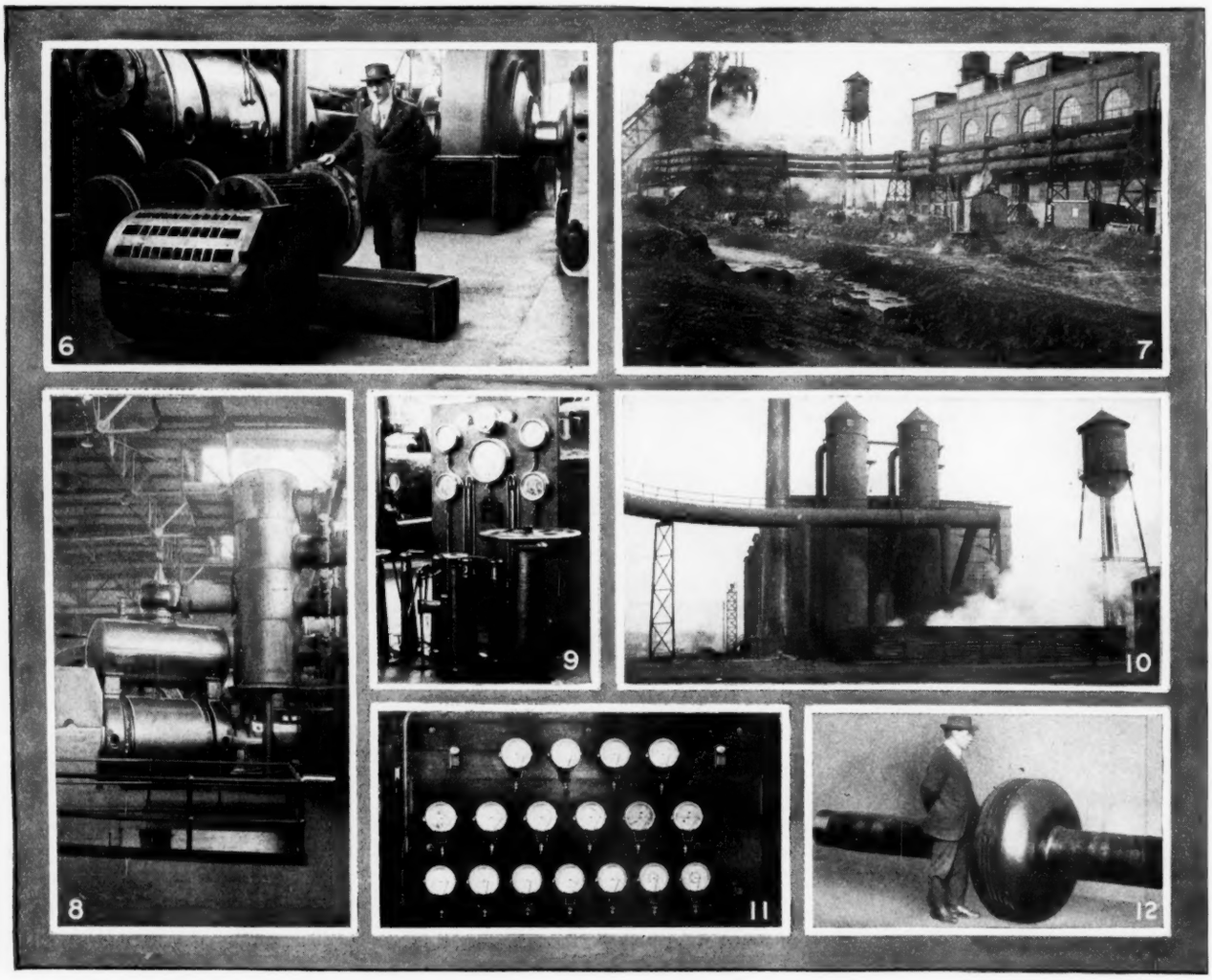
b.hp., which corresponds to a thermal efficiency of 26.8 per cent. based on the b.hp. or 30.1 on the gas i.hp.

No figures are available for the over-all efficiency of the plant, but judging by their size, the auxiliaries require but little energy in comparison with the plant output.

The consumption of cylinder oil is 1.8 gal. per engine per 24 hours. The bearing oil, which is also used in the governor relay, is filtered in an unusual but practical form of filter, and the apparent wastage of bearing oil for the past eleven months has been exactly nothing at all. This is due to the zeal of the chief engineer, Mr. Powell, who sought to remedy the former large consumption of 750 gal. per month. Upon investigation he found that practically all this oil was being burned in the cylinders, as there was a fault in the drainage system allowing it to be carried into the gas cylinder on the piston rod. A pipe costing $1.50 for each engine remedied the fault and saved 750 gal. of lubricating oil per month. Of such value can a chief engineer be when he is "on the job." This defect was a local one and not common to Bethlehem gas engines. However, there are some accretions of cylinder oil and governor oil to the bearing oil system.

The selection of reciprocating gas engines instead of steam turbines with gas-fired boilers is brought about primarily by the higher thermal efficiency of the latter type of prime mover. The efficiency of the internal-combustion engine plant, from gas to switchboard or blower, is about double that of the steam plant, average values being 25 and 10.5 per cent., respectively. In consequence, when steam only is used, the gas fuel is insufficient for all purposes and must be supplemented by coal. The cost of this coal, which is unnecessary when only gas engines are employed, is the controlling consideration, although past records show that the other items of steam-plant costs are lower (which fact, however, is likely to be altered with the further development of these large gas engines). These efficiencies are obtained from actual power plant records under steel mill conditions, and are used in the following comparison, although higher steam plant economies are claimed in mill practice than that quoted.

The installation cost, including buildings and ground, gas washers and all auxiliaries, is slightly greater for the gas-engine plant than for the steam. Recent records of



FIGS. 6 TO 12. VIEWS IN AND ABOUT THE SPARROWS POINT PLANT

Fig. 6—Air valves for blowing cylinder. Fig. 7—Air pipe lines at the back of the power house. A blast furnace is partly shown on the left. The excavation work in the foreground is for the new power house. Fig. 8—Air end of a gas blower, showing distributing valves. Fig. 9—Operator's board. Fig. 10—The two towers in the middle are the Zschocke washers; on the left is the stack for the exhaust gases, on the right the emergency water tower and in the foreground the cooling pond for jacket water, surrounded by a slatted fence. The pipe line is 78-in. diameter. Fig. 11—Recording instrument board. Fig. 12—Gas cylinder piston and rod

steel-mill power installations in the United States may be taken at $80 and $70 respectively, per kilowatt of rated capacity.

The relative depreciation of the two types of drive does not enter largely into the calculation, since both may be maintained in excellent condition year in and year out and are much more likely to be retired through obsolescence than through wear and tear.

Regarding repairs and maintenance, records at Sparrows Point for the second half of 1916 show that this total cost, labor and material, per blast unit (consisting of 1,606,000 cu.ft. blast, delivered against 15 lb. pressure, and equivalent to 1000 kw.-hr.) was 48.72c. for the steam blowers and 14.12c. for the gas blowers. On a kw.-hr. basis this is 0.04872c., against 0.01412c. in favor of the gas engine. These figures are of special interest in view of the general assumption that repair costs for gas engine power are greater than for steam. The actual records at Sparrows Point show that the former is only 29 per cent. of the latter.

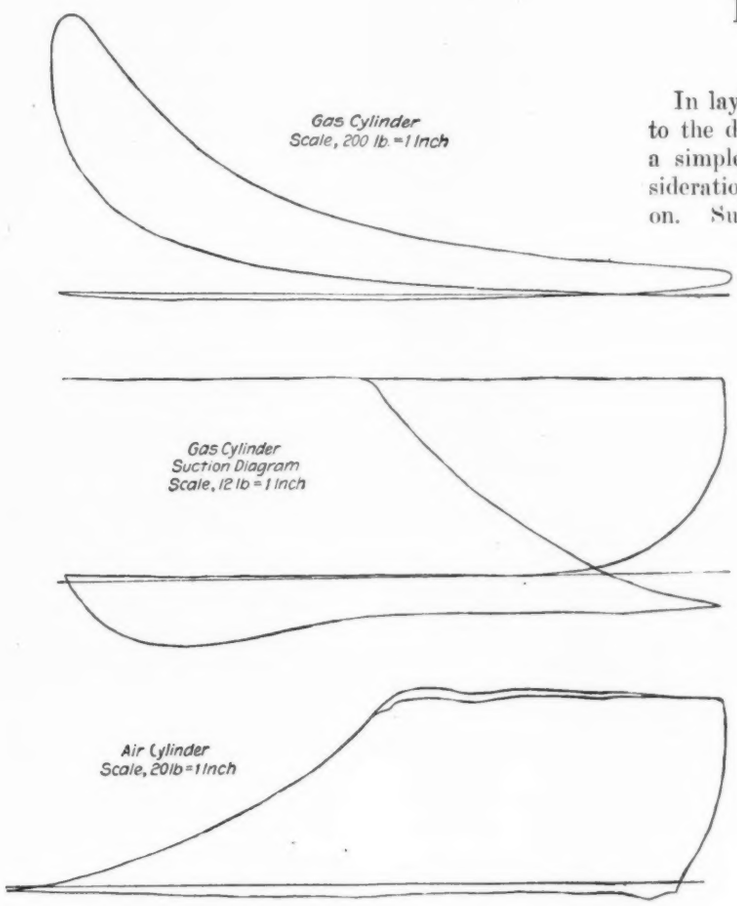


FIG. 13. INDICATOR DIAGRAMS. REPRODUCED FULL SIZE

A comparison of costs of power and the resulting estimate of the saving to be made through the use of gas engines are largely dependent upon the load factor of the plant and the cost of coal. The following figures are for a load factor of 66 per cent. and installation costs previously quoted. They do not include costs of labor, oil, water and miscellaneous supplies. The extra coal necessary for the steam plant is figured on a basis of $3.50 per ton for half the work delivered; and it is assumed that 3 lb. of coal will produce 1 kw. per hr.

The saving is thus 0.244c. per kw.-hr. and this for the coming Sparrows Point Plant, at $\frac{2}{3}$ load factor, will amount to more than $1,000,000 per year.

	Costs in Cents per Delivered Kw.-Hr.	
	Steam Plant	Gas Plant
Fixed charges at 15%	0.180	0.205
Repairs	0.049	0.014
Value of fine gas	0.174	0.174
Extra coal for steam	0.234	.....
Total Cost	0.637	0.393

Estimating the cost of labor, oil, water and miscellaneous supplies at 0.055c. per kw.-hr. (based upon results from similar plants), the total cost of power in the coming Sparrows Point plant will be 0.448c. per kw.-hr.

Acknowledgment is made to Mr. Powell for his courtesy in furnishing the data upon which this article is based.

Design of Steam-Pipe Lines

By L. A. Wilson

In laying out power plants too little attention is given to the design of steam-pipe lines. Although apparently a simple problem, it is one that requires careful consideration of the strains set up when steam is turned on. Suffice it to say that a steam pipe expands or contracts one part in about 1500 of length for each 100 deg. F. temperature variation. This is sufficient reason for providing in every case for sufficient free lateral action of the line. In order to avoid distortion of branch connections, it is sometimes necessary to anchor the line at certain points, and in that case expansion joints find application. Plenty of supports should be provided so that there will be no chance for the pipe line to sag at such a joint and cause it to bind. It is also wise to bear in mind that where expansion joints are used there is another force to be taken into consideration; namely, that due to the steam pressure acting parallel to the axis of the joint tending to force it apart. For example, 150 lb. per sq.in. acting on the sectional area of a 6-in. line would exert a total lateral thrust of more than 4000 lb., and firm anchorage at each end of the line is necessary to withstand this force. The importance of these considerations was recently brought to my attention. A 6-in. steam header 125 ft. long and arranged to supply several separate units was supported by angle-iron brackets bolted to vertical steel columns and anchored to a bracket at each end of the line and also to one in the middle, two slip expansion joints being provided to allow free expansion between these fixed points, all the other supporting brackets having rollers. After steam had been turned into the main, it was discovered that the end brackets were both bent outward two or three inches, and to all appearances the expansion joints had failed to function; but it is my opinion that the real cause was the additional end thrust.

The Number of Gasoline and Kerosene Tractors in use in the United States, according to a census by the Department of Agriculture, is 34,371. Of these the State of Illinois leads with 3202.

Commutators and Brushes

By Gordon Fox

SYNOPSIS—The troubles and their causes that are experienced with the commutator and brushes of direct-current machines are discussed, with recommendations for preventing and overcoming these defects.

It is imperative that the surface of a commutator be perfectly true and smooth if sparkless commutation is to be expected. A small roughness or defect may be sufficient to start slight sparking, but the condition is cumulative and a little sparking may easily be aggravated and lead to rapid deterioration of both commutator and brushes. Arcing under the brushes should be differentiated from arcing at the edge of a brush. Arcing under the brushes usually arises from some mechanical cause preventing perfect contact; vibration, high mica or light brush tension are instances. Arcing at the edge of the brushes generally indicates unfavorable electrical conditions such as excessive short-circuit current. High mica is also responsible for much commutator trouble.

Comparatively slight sparking may serve to burn away a little copper from a few segments, leaving the mica projecting to a minute degree. These raised mica segments introduce a slight separation between the commutator surface and the brushes; the current must jump across this gap, and small pin sparks under the entire brush may be seen. These minute arcs lead rapidly to blackening of the copper surface and will most likely occur first at one or two bars. When these bars are under the brushes, they shirk the load, since they afford poor contact and cause the current to shift to other brushes of like polarity, which then carry more than their proportionate share of the load. Burning is then likely to start at these points, and the commutator becomes marked at a number of equally-spaced sectors, there being half as many spots as there are brush studs.

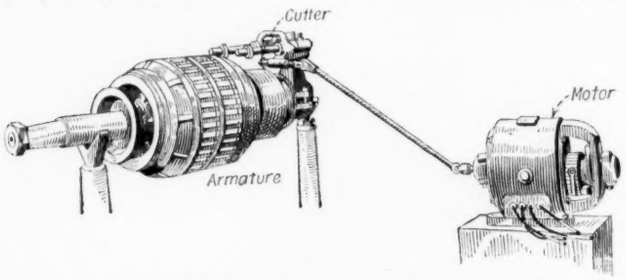


FIG. 1. MOTOR-DRIVEN TOOL FOR UNDERCUTTING MICA IN COMMUTATORS

Blackening of the copper is usually attended by high mica inasmuch as the copper is then burned away more rapidly than the mica can be abraded or worn off. The presence of high mica is usually evident from the appearance of the commutator and the sparking under the brushes. It may also be detected by examination of the commutator surface and is at once manifest if the finger nail be drawn across the commutator segments. Undercutting the mica is the remedy most frequently applied where the trouble is of a recurring nature or where electrical or other conditions are such that a slight burning of the copper is almost inevitable, and many cases of trouble are relieved by this means. Where the mica is undercut, any slight burning of the copper may be worn off without the probability of serious results, as already outlined. In plants handling many direct-current machines, special undercutting tools are often found; a tool for this purpose is shown in Fig. 1. For the occasional job a hacksaw blade or riffle file, if skillfully used, can perform a thoroughly satisfactory job. Undercut commutators afford some liability of dirt collection in the slots, which must be avoided by frequently brushing out between bars if the centrifugal force of rotation does not serve the same purpose. Since the presence of oil encourages accumulation of dirt, the use of lubricant on an undercut commutator is a questionable practice.

A commutator should be perfectly round and accurately centered upon its shaft, particularly in the case of high-speed machines. Commutators sometimes become out of true owing to heating strains or seasoning processes. Being subjected to simultaneous heating and rotation, they sometimes yield slightly while new. Such commutators may require truing once or twice before they reach their final set.

Baking and Tightening of Commutators

All commutators are baked when built, this process allowing the shellac binder to flow and give. After repairs have been made, the same heating process should be repeated, and can be most easily accomplished, particularly upon large machines, by running the machine short-circuited. The brushes are shifted somewhat off neutral, the armature leads are connected together through an ammeter, and the fields are separately excited and regulated so that approximately full-load current flows through the armature circuit. The machine is operated as a generator, being driven by any convenient means. Some sparking will occur. This, together with the short-circuit current and the local currents in the brushes off neutral, heats the commutator thoroughly. When uniformly heated, it should be tightened by means of the end bolts, and after cooling, the bolts should be again gone over and any looseness incidental to the cooling contraction taken up. In tightening the end bolts of a commutator, it is best to rotate the armature several times and take up a little on each bolt each time, thus causing the collar to enter square and true. If the machine is compounded, the series field winding must be cut out when running it short-circuited.

Practically every commutator requires an occasional turning, which for all ordinary motors can be accomplished to best advantage in a lathe. With large machines the commutators may be trued in place without dismantling, but all end play must be taken from the shaft before doing so. This can usually be done by making a wedging device. There are many different designs of truing devices, each comprising essentially a tool support with a screw for feeding by a handwheel. Some devices are bolted to the bearing pedestal, some to the brushholder ring, but rigidity is the most desirable quality and one to be demanded.

If the commutator has open risers, it is well to place a cardboard shield in front of them to prevent copper chips from lodging internally in the windings. The brushes

should be raised before the turning is commenced, and before again lowering them, they should be cleaned and all copper dust removed. After truing a commutator, a file may be used for removing the tool marks, but it should be used sparingly to prevent untruing the surface. Finishing may be done by means of fine sandpaper on a formed block. If the sandpaper is oiled slightly on its reverse side, it will pick up the copper dust and leave the surface clean. A fine sandstone is considered by the author to be preferable to sandpaper as it abrades the entire surface uniformly, whereas sandpaper gives slightly and rides over the mica. A sandstone block is even substituted for the cutting tool in some cases and the entire truing done by abrasion. Undercutting the mica, where practiced, is done after the armature is trued. After undercutting it is well to round the edges of the copper segments slightly so that they will not unnecessarily cut the brushes or cause them to vibrate.

Treatment of Commutator After Turning

Any commutator should be thoroughly inspected after turning, to detect and remove particles of copper dragged across from one bar to the next in the turning operation. It is a good practice to round the outer edge of the commutator considerably, as shown at *A*, Fig. 2, as a sharp corner is found to be more vulnerable to oil attack in the mica. It is also well to paint the outer end of the commutator next the bearing after turning, as the paint serves as a protection against oil. After a commutator has been turned or trued, it is best to run the machine for a time without load, with a comparatively heavy brush tension, for no matter how carefully finished, a commutator is comparatively raw until worked in and glazed. After the machine has seen a few hours' service, it is well to raise the brushes and remove any particles of copper that may have accumulated. A raw commutator is very likely to cause the brushes to pick up copper, and this, in turn, is likely to start trouble through selective commutation, glowing and pitting.

Materials Used in Brush Construction

Brushes are commonly made of carbon, graphite or combinations of the two, together with flaked copper, abrasive materials and a binder. Flaked copper is used only where high-current density is required. The mixture is formed into blocks or slabs and baked; then the brushes are obtained by sawing and grinding to size, followed by copper plating and tinning, according to design. Brushes may have a wide range of qualities, depending upon their constituents. Hard brushes usually carry a large amount of abrasive material and have a low current density or carrying capacity. Soft brushes contain a large percentage of graphite with a small amount of abrasive material, and have a high current capacity.

Carbon is used as the base material for brushes largely because of its high contact resistance. The brushes short-circuit the coils connected to the bars which they span; the resistance of these short-circuited coils is comparatively low, particularly in large-capacity machines. The short-circuited coils have generated in them a pressure of two or three volts, consequently, if the commutator bars are spanned by copper brushes, the resistance of the local circuit will be so low that very poor commutation will result from the large current. Since a voltage is almost inevitable in the commutated coils, it becomes necessary to reduce the consequent current by increasing the resistance of the local circuit. This can be readily done by using carbon brushes which have a relatively high contact resistance. When carbon brushes are used, the resistance from bar to brush and back to bar is about twenty times as great as when copper brushes are used. The great reduction in short-circuit current flow is at once evident. This resistance does not greatly influence the action of the machine, as it is relatively small compared with the total voltage, but relatively large with respect to the local voltage in a short-circuited coil.

In higher-voltage machines, 550 volts for instance, there are more turns per armature coil than in low-voltage machines, consequently the voltage across commutated coils is likely to be higher. To retain the short-circuit current within the desired limits, it is usually necessary to use a brush having comparatively high resistance qualities for the former, whereas a lower-resistance brush will suffice for the latter.

The brushes of a machine must be able to carry the maximum current which they are called upon to transmit without undue heating. There are two currents involved —the normal work current and the short-circuit current due to commutation. The short-circuit current may be comparatively small or it may be high, depending upon

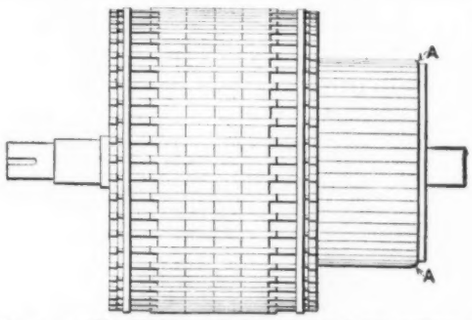


FIG. 2. ARMATURE SHOWING OUTER EDGE OF COMMUTATOR ROUNDED

the design of the machine, its service and the conditions of operation. Many brush troubles are due to high short-circuit current caused by incorrect brush setting or other operating features. Interpole and low-voltage machines have their brushes worked at a higher density than their opposite types. A current density of about 40 amp. per sq.in. of area is considered a conservative value.

The quality of the brush selected depends upon many conditions. Abrasive brushes are generally used where there is a tendency for the copper to be burned and where the mica must be kept worn down. For example, on railway motors the commutators receive hard service and highly abrasive brushes are often used. On the other hand, soft graphitic brushes are used where wear must be minimized. For instance, high-speed generators of the turbine-driven type are usually equipped with graphite brushes. The peripheral speed of the commutator being high, the brush friction must be reduced as far as possible. Soft or graphitic brushes are also much used upon commutators having the mica undercut. In this case no abrasive action is required and the graphitic brush rides more smoothly and imparts a polish to the commutator surface. Graphitic brushes and soft brushes, in general, have lower resistance than harder brushes and thus tend to encourage short-circuit current. This point

must be borne in mind in selecting the brush quality. Low-voltage machines, such as those for electrolytic work, are quite commonly supplied with brushes containing flaked copper. Brushes of this type can be worked at high-current densities and are therefore suitable for heavy-current machines.

The character of the brushholder used influences the service afforded by the brush. The brushholders used on most modern machines are now of good design. The box-type holder, Fig. 3, is to be preferred, but the boxes should be true and the brushes should fit snugly, not tight enough to bind or loose enough to rock. A large number of holders is desirable on high-speed machines because subdivision of the brushes decreases their inertia and prevents their being thrown off the commutator. A positive- and quick-acting spring is necessary to return the brush quickly after any lifting influence. The spring should be arranged to maintain uniform tension in spite of brush wear.

Box-type holders should be adjusted so that they clear the commutator about 0.125 in. They can all be uniformly set to this spacing if a strip, such as a piece of cigar box, is inserted between holder and commutator and the box set down to this gage. The copper plating on the sides of the brushes should always be kept scraped off for a distance of about 0.25 in. from the end. If this copper is allowed to touch the commutator, the current will be localized at this point because of the lower resistance of the copper. The angular position of brushholders is

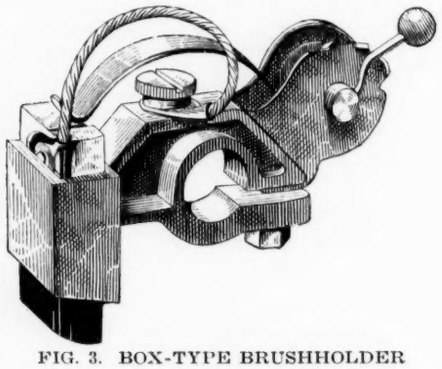


FIG. 3. BOX-TYPE BRUSHHOLDER

sometimes important; reversing motors are best operated with the brushes set radial unless operation in one direction predominates. Brushes on other machines should make an angle of about 15 deg. with the radial line, the outer end of the brush being in advance of the face. The brushes should be in front of the stud. This arrangement causes the brushes to be forced onto the commutator rather than lifted from it by any irregularities.

The brush shunt is an important part of the current-collecting provision. Its function is to conduct the current from the brush to the brushholder or stud. Were no shunt supplied, the current would arc from the brush to the sides of the box holder, roughen the surfaces and cause jamming, or else the current would pass through the brush tension spring and destroy it. Even where shunts are provided, these conditions may occur if the shunt is not ample in size and well attached both to the brush and to the stud. The method of attaching the shunts to the brushes is important, many brushes being defective or but partially satisfactory in this regard. Screwed-on shunts are easily interchanged, but are liable to poor contacts at some brushes, resulting in selective commutation. Spun or riveted attachments are sometimes satisfactory. Shunts that are first mechanically attached and then sweated, or which are embedded in metal cement in a tinned recess, are probably the preferable types.

Brushes should be kept clean, deposits upon the heel of the brush occasionally removed and material gathering between brush and holder prevented from causing the brush to stick. The latter action leads to broken or jammed brushes and consequent flats on the commutator.

It is almost impossible to accurately shape up the face of a brush by removing it from the holder. The correct curvature can be most effectively attained by drawing strips of fine sandpaper under the brushes, holding the paper close to the commutator to insure proper shaping. Brushes in box-type holders have more or less rocking action. They should be sanded by drawing the paper in one direction only—the direction of rotation—by lifting the brushes when the paper is moved in the reverse direction. This practice insures that the brushes will fit the commutator when the play is taken up by the rotation of the armature. In motors that operate in both directions some slight rocking is inevitable, but this should be minimized by properly fitting the holders and the brushes. Narrow brushes tend to rock more than wide brushes, but the rocking action does not shift the zone of contact to so great an extent.

The Effects of Brush Tension

Brush tension is a factor of considerable import. Heavy pressure improves the contact and lowers contact resistance slightly, but it increases friction and abrasive action, heats up the commutator and brushes and leads to rapid wear. The best pressure, in any case, is the lowest which affords good contact with freedom from chattering, sparking and pitting. Different classes of service call for different brush pressures. Ordinary generators and motors should have a tension of 1.5 to 2 lb. per sq.in. of brush area. Crane and railway motors and similar applications call for higher pressures, 4 to 7 lb. being common values. Relative tensions can be approximately determined "by the feel," but the use of a small spring scale as shown in Fig. 4 is more dependable.

The frictional loss at the brushes depends upon the brush material, the brush angle and the commutator speed, as well as the brush pressure. The condition of the surface has a marked influence, a glazed face affording much less friction than when raw or pitted.

A little lubrication of the brushes now and then is beneficial in the great majority of cases, but it may be easily overdone. Commutators should be kept clean, and this can most readily be done by wiping with a dry rag (never use waste) or one having but a trace of dynamo oil. Heavy lubricants such as vaseline, paraffin or special preparations should not be applied to dirty commutators, as they cause the dirt to adhere and stick in the mica segments. The commutator should be cleansed first, then lubricated if necessary. Paraffin is recommended as a lubricant, but it should be applied only when the commutator is warm enough to melt it, otherwise it will gum, and should be used very sparingly. Paraffin and tallow should not be confused (as in candles) as tallow is injurious to the mica.

It is important that the brushes be symmetrically spaced. Machines having wide neutral zones may perform satisfactorily even with the brushes inaccurately located, but the performance of sensitive machines may be greatly influenced by brush spacing. Also, if the brushes are incorrectly spaced the effect of "off neutral" operation is more serious as the voltage unbalancing is then emphasized. Brushes can be correctly spaced most easily by cutting a strip of paper about an inch wide and exactly equal to the circumference of the commutator. The strip is then equally divided and marked to correspond to the number of poles and again placed around the commutator and the brushes adjusted to the division marks. This procedure is more accurate than counting the segments and attempting to thus equalize the distances.

The Correct Location of the Brushes

It is important that the brushes be located in the zone of minimum voltage between adjacent segments because the brush spans two or more segments, short-circuiting them. The method for properly locating the brushes depends upon the type of machine. In ordinary noninterpole types the neutral zone shifts with variations in load. The shift is in a direction with the rotation in the case of a generator and against the rotation in the case of a motor. Generator brushes should be shifted as far with the rotation as will afford good commutation at no load; while motor brushes should be shifted against the direction of rotation. In an interpole machine the neutral position should remain fixed at all loads. The best way to locate the brushes of an interpole machine is to run the machine first in one direction, then in the other, changing the brush position until the speed is the same in both directions. If the motor is of the adjustable-speed type, this adjustment should preferably be made with full field to locate the brushes approximately and with weak field to locate the brushes finally and with greatest accuracy. There are other methods of locating the brushes in interpole machines the discussion of which would require considerable space.

In all but the smallest and simplest machines, there are many brushes acting in parallel. It is not always easy to secure equal division of load among these brushes; several causes may contribute to unequal load division. Differences in brush tension or inequality of air gaps are common causes. If a brush takes more than its share of the current for a time, that brush heats and, because of its negative temperature coefficient, its resistance is lowered and it tends to assume even greater current than before. It may become so hot that it glows, and the surface is then burned slightly and the contact resistance increases so that the load through the brush drops off. Where there are many brushes in parallel, involving a large total current, it is easily possible for one brush to assume an excessive load without materially decreasing the load carried by the others. With but few brushes in parallel, the division is more likely to be uniform.

When current passes from the commutator to a brush, it tends to carry with it minute particles of copper. This action is sometimes electrolytic, although in reality it is probably attributable to slight arcing, the particles of copper being burned away from the commutator and deposited upon the carbon. The action is usually more pronounced under the brushes into which the load current enters; that is, the positive brushes of a generator and the negative brushes of a motor. It is possible for the trouble to occur at the other brushes also, since the short-circuit local currents both enter and leave each brush, regardless of the direction of flow of the load current. Picking up copper, as this action is commonly termed, is likely to lead to trouble, the deposits appearing as spots under the brushes. These spots are points of low resistance which allow excessive short-circuit currents and which localize the load current. The lowered resistance may also affect the load division and lead to selective commutation, as already mentioned. In staggering brushes to secure equal wear, it is well to stagger in pairs rather than by alternate studs, as the latter practice places all studs of each polarity in line and does not correct for differences in wear under brushes of differing polarity.

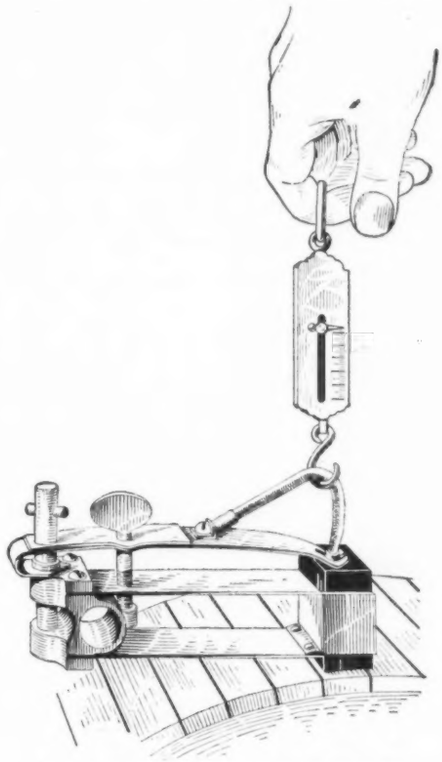


FIG. 4. TESTING BRUSH TENSION

There are occasional, though rare, instances when it is found advisable to "mix" brushes; that is, to use brushes of different characteristics on different studs. It is not advisable to use different brushes in holders on the same stud because of unequal load division which might ensue. The practice is sometimes followed, however, of placing special lubricating brushes, such as graphite brushes, spirally about the commutator, one on each stud, to provide proper lubrication for the remainder of the brushes. These lubricating brushes should have no shunts and should not be expected to carry much load current. Likewise, in other instances specially abrasive brushes can be similarly employed.

To Convert Centigrade to Fahrenheit Reading—One degree C. equals 1⅘ deg. F., therefore multiply the Centigrade reading by 9 and then divide by 5, then add 32 to get the Fahrenheit reading. To change Fahrenheit to Centigrade reading, first subtract 32, then divide by 9 and multiply by 5.

Relative Movement of Crank and Crosshead

Everybody who has given any attention to valve gear and valve setting knows that the movement of the piston and crosshead is not the same in both ends of the cylinder

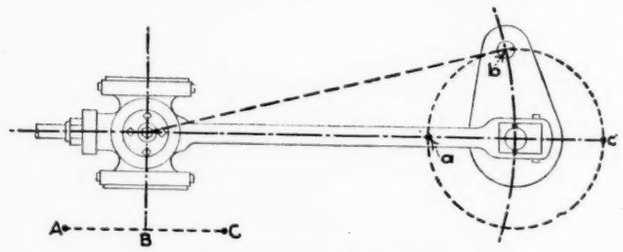


FIG. 1. SHOWING THAT PISTON HAS MADE HALF THE STROKE WHILE THE CRANKPIN HAS PASSED THROUGH LESS THAN HALF THE SEMICIRCLE

for the same angular motion of the crank. This is shown very simply and convincingly as follows:

With the connecting-rod unshipped from the crankpin, place the center of the crankpin box in line with the

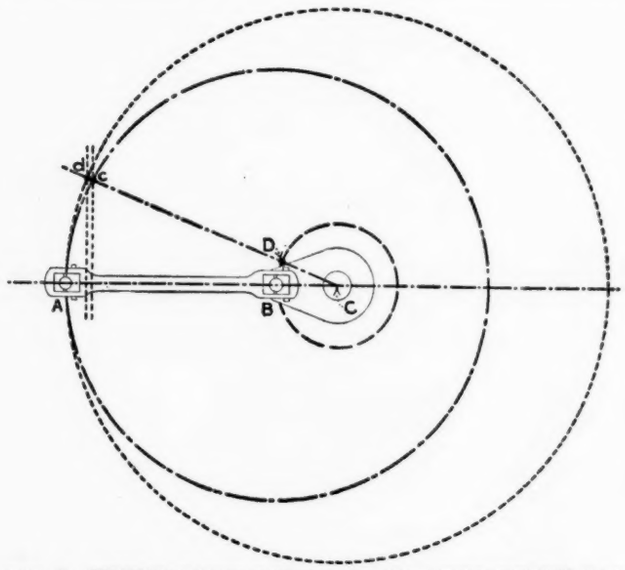


FIG. 2. SHOWING THE DISTANCE THAT THE PISTON HAS TRAVELED WHEN THE CRANK IS IN A GIVEN POSITION

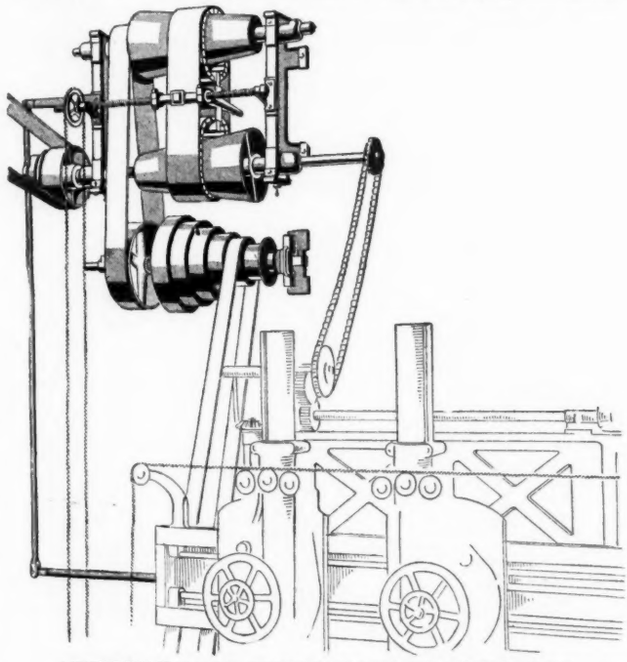
mainshaft center as in Fig. 1. The crosshead will then be in its central position. Now swing the rod up and connect it to the crank as shown in the dotted position, and it will be seen that the crank is considerably less than one-half of the semicircle from the dead-center *a*. The head-end half *AB* of the stroke has to be made while the crank is going from *a* to *b*, but the piston has all the time that the crank is going from *b* to *c* to make the other half *BC* of the stroke. As the motion of the crank is substantially uniform, this means that the motion of the piston in the head end is faster than in the crank end, and that for a given motion of the crank there will be less piston movement at the crank end than at the head end of the stroke. The shorter the connecting-rod with relation to the crank the greater will be this discrepancy; in Fig. 1 the connecting-rod is only 3.5 cranks long in order to emphasize it. In practice rods are made five or six times as long as the crank, and the distortion becomes less noticeable, but still important in designing and setting valve gear.

A simple method of laying off the piston movement for any position of the crank is shown in Fig. 2. From the center *C* with a radius *AC* proportional to the combined length of the connecting-rod and crank, draw the larger circle. From the center *B* representing the position of the crankpin on the center line and with the radius *AB* proportional to the length of the connecting-rod, inscribe the smaller circle. Then for any position of the crank, as *CD*, the motion of the piston will be proportional to the length *cd* intercepted on a prolongation of the line *CD* by the two circles. A mathematical demonstration of the truth of this proposition was presented in the *Schweizerische Bauzeitung* by Herr Ing. Halvor Andresen, of Christiania, who claims to have discovered it and probably did work it out without knowing that it was demonstrated by Professor von Müller, of Stuttgart, in 1859 and published in the 1871 edition of Zeuner's well-known book on valve gears.

Speed-Change Cone Pulleys

An improvement in the speed-changing features of a cone-pulley drive is that of using what is termed a cone-pulley transformer, which is placed between the belt and the cone so that each cone is built up from a conical to a cylindrical surface. The illustration shows how the drive is used in connection with a boring machine. The step pulley is used only for extreme changes in speed ratio.

The transformers each consist of a series of tapered leather strips riveted to an endless belt, the strips being so formed as to give a crown like that of an ordinary pulley. These transformers are shifted along the cones by a screw and handwheel without stopping the machine. Where the drive is beyond reach from the floor, the screw



APPLICATION OF CONE-PULLEY TRANSFORMER

is operated by a chain and sprocket. When the transformers are in contact with a cone, they run as if they were a part of it. The angle of the cones is such that there is no tendency to slip or creep endwise. The belt may be of any desired width up to the width of the transformers. The device is manufactured by the Moore & White Co., Philadelphia, Penn.

Steam-Engine Troubles—Erecting

By H. Hamkens

SYNOPSIS—To successfully erect a high-grade engine a host of little details must be cared for. This article treats of each in the language of the man on the job.

In erecting the engine the frame is put in place first and leveled. Next, the cylinder and front head, with a gasket between them, are moved to the frame, leveled and bolted on. A plain soft-copper ring of even thickness seems to give the most satisfaction as a gasket; it may be put in dry or, better, covered with a mixture of oil and graphite. The center line of the engine must be located with the help of the targets. For this purpose two stands made of boards are fastened to the floor—one at the cylinder and the other at the crank end of the frame, as shown in Fig. 177. A fine silk line is stretched between the two as tightly as possible to avoid any sag. This line must be placed accurately by plumbing down from the original line, and the stands are notched so that the line may be taken off at any time and replaced. Next, the cylinder and guides are adjusted to this line as closely as it can be done by calipering. The line is then removed and centers are established in the rear end of the cylinder and the crank end of the guide by placing strips of wood in them, as shown in Fig. 178, each with a 1-in. hole in the middle covered by a piece of tin. The centers are marked with a pair of centering calipers, as shown; two centering lugs should be placed and machined for this purpose in every frame. A small hole is drilled with a sharp awl through the centers marked on the tin, and the silk line is stretched through them for a test. If the holes are not in line with the marks on the stands, bed and cylinder must be shifted and wedged up to suit. On long engines a centering strip with a hole should be placed in the piston-rod stuffing-box, and the guide must be checked at the cylinder end for central position. Before placing the frame, cylinder or any other heavy castings on the foundation, it is advisable to check the holes for the foundation bolts and mak. sure that they correspond with those in the foundation. It sometimes happens that the holes in the frame are not cored all the way through or

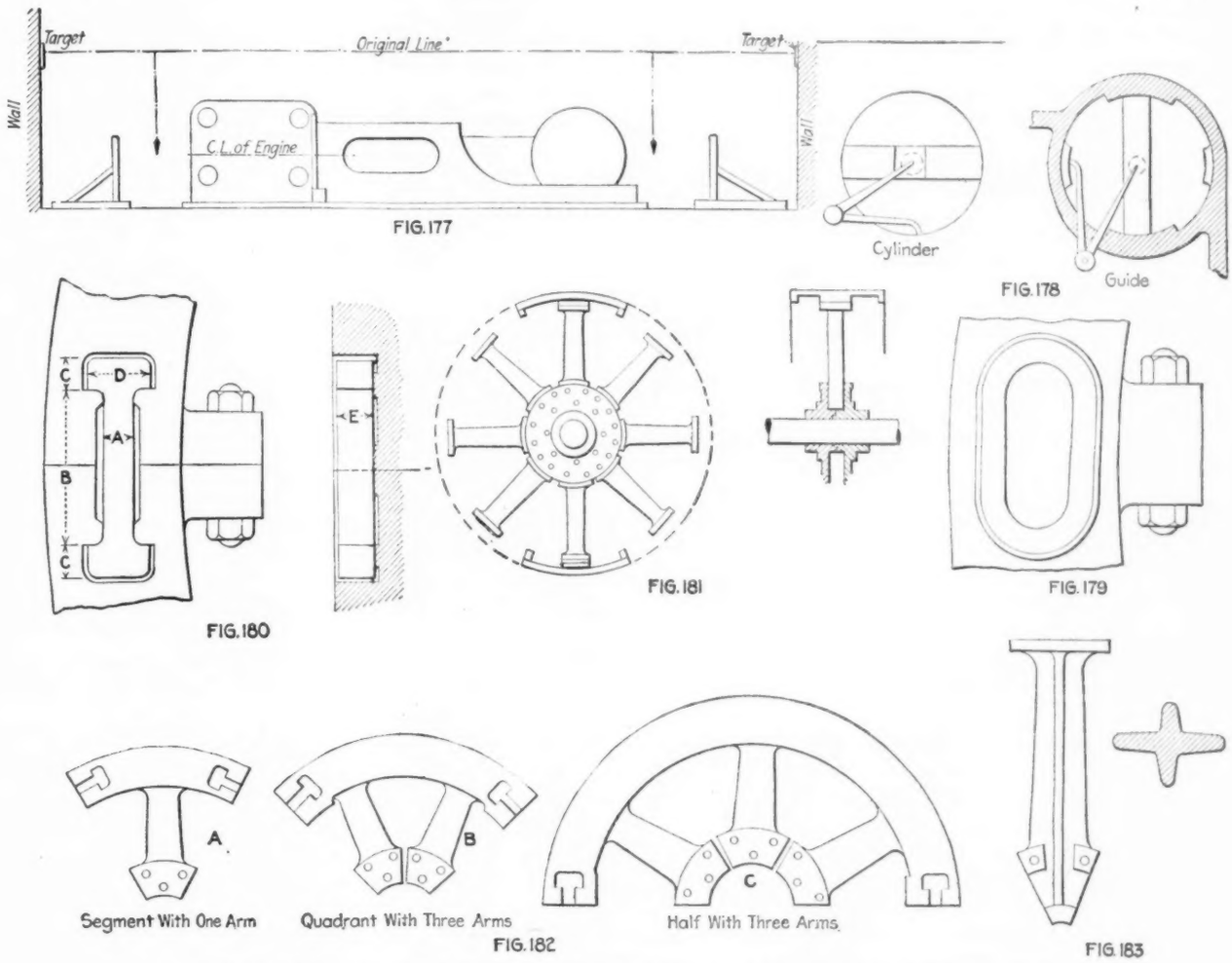


FIG. 177

FIG. 178

FIG. 180

FIG. 181

FIG. 179

FIG. 182

FIG. 183

FIGS. 177 TO 183. LOCATING ENGINE CENTER LINE, ALSO SHOWING FLYWHEEL PARTS

Fig. 177—Locating center line with aid of targets. Fig. 178—Calipering the cylinder and guides. Fig. 179—Old-time oval ring for flywheel joint. Fig. 180—The modern tee-links for flywheel joint. Fig. 181—Flywheel rim in segments. Fig. 182—Flywheel parts. Fig. 183—Rib section flywheel arm

that they are crooked and must be bored out. Any discrepancy of this kind is much easier made good before the frame is placed in position than after. The safest way is to test every hole with a piece of pipe or a bar of the same diameter as the bolt.

As soon as the engine is aligned and leveled by the use of steel wedges and plates, the foundation bolts are drawn up moderately tight without springing the castings. On large work the anchor bolts should not be put in until the engine is in place. The outer bearing is next placed on its foundation, lined up with the cross-line stretched at right angles to the center line of the engine, as previously described, and adjusted to the same level as the main bearing by the use of a straight-edge. On direct-connected units the sole plates for the generator are placed in position to suit, leveled and squared by the center line of the shaft. The crankshaft is put into the bearings, leveled and squared. In turning the crankpin to either of the dead centers the distance from the face of the crank to the center line of the engine can be checked. Placing the crankpin in the upper and the lower vertical positions and measuring the distance from the face of the crank to a plumb-line touching the main center line, will show whether the shaft is level and square with the engine. All four distances must be alike; if there is any difference, the shaft must be adjusted to suit.

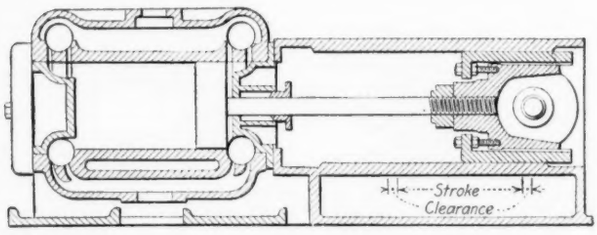


FIG. 184—CLEARANCE MARKS ON GUIDES

The engine is now ready for grouting. A dam of bricks or boards, banked with sand on the outside, is built three or four inches from the castings all around the parts to be grouted, and a mixture of one part of cement and one part of sand stirred in water to the consistency of thick cream is poured in. The dam should be about two inches higher than the base of the castings to make the grouting rise well into the inner part of the frame and sole plates. All air pockets must be vented and the grouting stirred while it is flowing to keep the heavy parts from settling. On large frames holes for grouting are sometimes provided in the crank pit, main pillow block and crosshead guides, which are closed afterward by special covers or regular pipe plugs. Ribs are often cast on the under side of sole plates and frames to give them a more substantial grip on the foundation, especially on rolling-mill engines where an end-thrust on the shaft is likely to occur. To plane the under side of bedplates to be grouted is a waste of time; the rougher the surface the better the grouting will hold.

From one to two days is required for the grouting to set; the dam can then be removed and the wedges and plates be drawn out, after which the holes should be filled with cement and the grouting trimmed off all around the outside. In a few days the foundation bolts may be drawn up tight.

Rust and sulphur joints should not be allowed to be put under an engine; they are antiquated, expensive and unreliable—especially sulphur, which gets brittle and is easily affected by oil.

While the masonry is being done, all machined parts of cylinder, frame, etc., should be covered with a coat of cylinder oil; crankpin and shaft must be protected with burlap, and oil holes and handholes should be filled with waste.

The flywheel may now be erected and also the generator if the engine is direct-connected. If the wheel is made in halves, it is advisable to lower one-half into the flywheel pit before the shaft is put into the bearings; it should be blocked up tight against the shaft, the other half placed over it and the two connected by means of the hub bolts, which are generally heated before they are inserted. In cooling they will contract and, with the nuts drawn up tight, will give the wheel a good grip on the shaft. In order to make the hub fit well, it should be bored two or three thousandths of an inch smaller than the diameter of the shaft, and a space of not less than $\frac{1}{2}$ in. allowed between the halves for clamping. A feather secured in the shaft and made a good fit on the sides of the keyway in the hub is much to be preferred to a driven key, which should be used only on a solid hub. The rim bolts are put in and tightened and the nuts and bolts are prick-punched to keep the former from backing off. If the rim is held together by links, they must be measured and checked with the recesses to make sure that they will fit. The links are heated and when sufficiently expanded ($\frac{1}{32}$ to $\frac{1}{16}$ in. longer than the recess, according to size) they are put in place.

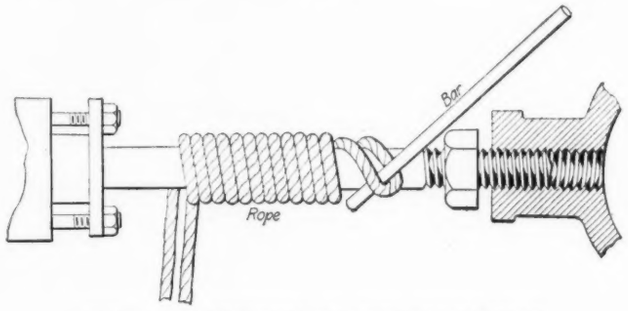


FIG. 185. SCREWING IN THE PISTON ROD

The old-time links made in the shape of an oval ring, as shown in Fig. 179, are seldom used on new wheels. If welded they are not safe to use; there is never any certainty that a weld is solid even if it appears so on the outside. The rings are sometimes cut out of solid steel, but since they cannot be machined accurately, they can never be made a good fit. Tee-head links, Fig. 180, are the only ones that can be recommended. They should be made of openhearth forged steel of 0.25 to 0.30 carbon. To use cast steel for this purpose is dangerous for neither the quality nor the strength can be relied upon. In order to make the link construction equal in strength to the rim section, the following proportions should be adopted:

$$B = 5A : C = A : D = 2A : E \text{ not less than } A$$

The steel in tension and shear should be 20 per cent. of the rim area, and the cast iron in tension and shear should be equal to the rim area. On belt and rope wheels, where bolts are used almost exclusively, the area at the root of the threads in each joint must be not less than 25 per cent. of the rim area The joints in the rim

should be planed, and on belt and rope wheels at least one bolt in each joint should be turned and fitted in the hole to prevent side motion. Split joints never make a first-class job.

On a segmental wheel with two solid hub centers on the shaft and arms and rim sections cast separate, the arms are put in first and the rim sections bolted on afterward. It is likely that the wheel was never before in a vertical position, but was erected on the floor and turned in a vertical boring mill in a horizontal position. It is therefore advisable not to drive home the bolts right away, but to leave about one-half inch between the head and the face of the hub. The bolts and holes should taper $\frac{1}{8}$ in. per foot; straight bolts should not be used on this class of work. With the arms all in place, each segment is put on its respective arm in the vertical position, as shown in Fig. 181, in which it can easily be set to the lines marked in the shop. Two of the bolts connecting the arm and segments must be fitted. It is well to erect the segments opposite each other to keep the wheel as nearly balanced as possible. No bolts connecting the segments should be put in till the last segment is in its place. As the work progresses, a check can be kept on the spaces between the segments by measuring the respective chords, which should be given on the drawing of the wheel. With all the segments located, the rim bolts can be put in and tightened and the hub bolts driven home. In a well-designed wheel each arm must be able to support its segment independently of the others and the segments should come together without forcing. Bolts used on flywheels should have a fillet under the head equal to $\frac{1}{16}$ of their diameter.

Shrinkage strains and blowholes in castings and the restrictions of the transportation companies as to size and weight are responsible for built-up wheels. The number of pieces and joints in wheels should be kept as low as possible. On large band wheels it is not feasible to cast the segments and arms together, but on square-rim wheels at least one segment and arm should be cast in one piece. Of the three designs in Fig. 182, *A* shows a segment with one arm, *B* a quadrant with two arms and *C* a half with three arms cast on. There is no connection between the arms at the hub, leaving them free to contract in the mold without offering any resistance to free shrinkage of the rim. It is not good practice to make flywheels with a large number of frail arms; the arms must be in proportion to the rim. Light rims and light arms are gradually disappearing; wherever they are still in use, there is constant danger of accidents. Rib-section arms, as shown in Fig. 183, should be avoided, they may develop cracks near the outer flange and, if run at considerable speed, throw off the air like a fan.

The oval arm has proved to be superior to any other shape and should always be used. Each arm should have three holes for bolting it to the hub centers—two holes, as shown in Fig. 183, are not sufficient. The practice of

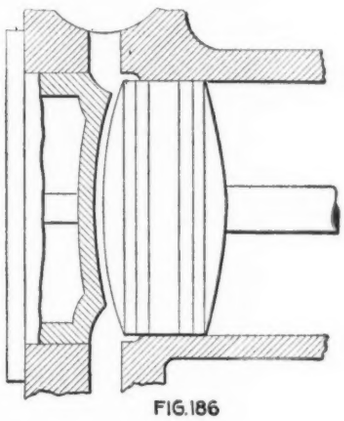
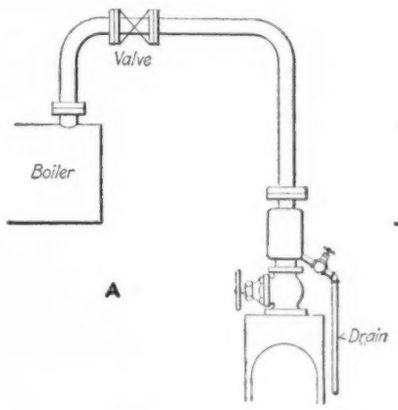


FIG. 186



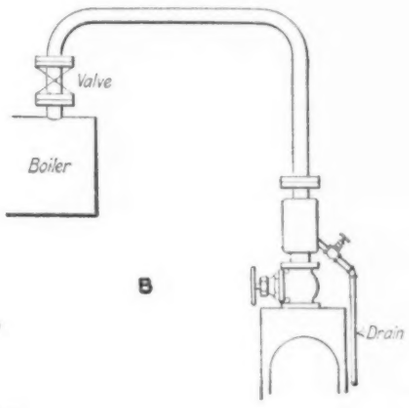


FIG. 187

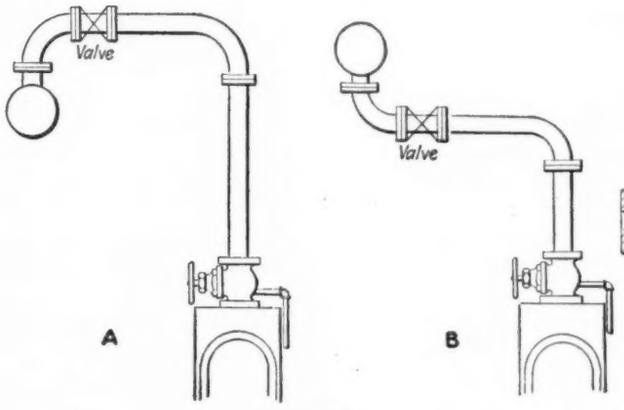


FIG. 188

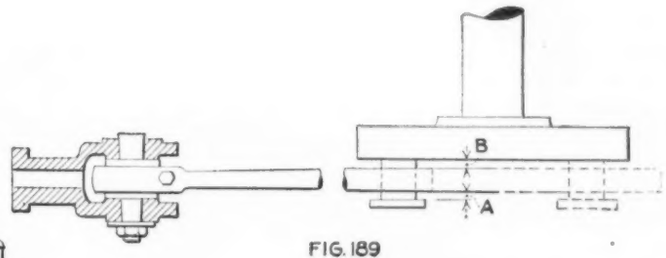


FIG. 189

FIGS. 186 TO 189. CORLISS-ENGINE PARTS AND STEAM-PIPE LAYOUTS

Fig. 186—Piston with curved faces. Fig. 187—A shows a correct and B an incorrect steam main. Fig. 188—No water can collect in the layout A if the drip valve is open; but B will collect condensate. Fig. 189—Determining if the crosshead and crankpins are in line and parallel

casting rim and arms hollow cannot be recommended, as the cores might shift in the mold, which would distribute the metal unevenly and make the wheel unsafe. Wheels, like steam cylinders, should be cast of a special grade of close-grained iron, which has no tendency to form blowholes. Iron showing an open texture is not suitable, even if a test bar of it should show high tensile strength. In fact, test bars hardly ever represent the actual strength of a casting unless they are cut out of solid metal of the same thickness as the segment or arm and cast either in one piece with them or under exactly the same conditions and from the same ladle. Small bars, whether cast on or loose, are of no practical value.

The stress in the rim of cast-iron wheels, resulting from centrifugal force, must not exceed 1000 lb. per sq.in. The simplest kind of calculation that can be made will show whether this figure is exceeded in a wheel or not: Multiply the outside diameter of the wheel in feet by 3.14, which will give the circumference; multiply this by the number of revolutions per second, square the product and divide by 10. As an example, take a 15-ft. wheel running 120 revolutions per minute. On heavy square-rim

$$15 \times 3.14 = 47.1$$

$$47.12 \times \frac{120}{60} = 47.1 \times 2 = 94.2$$

$$\frac{94.24^2}{10} = 887 \textit{ lb. per sq.in.}$$

wheels the bending stresses are negligible, but in belt wheels they must be carefully considered.

The cylinder must be thoroughly cleaned in the ports. Steam and exhaust chests and bore are blown out with steam or air. All core sand left in the casting or grit blown into it in transportation or erecting must be removed. The throttle valve should be put on, making the engine ready for the pipe connections to the boilers. The piston, rod and crosshead should be put in and lined up.

The guide should have marks at each end to indicate the length of the stroke and the clearances in the cylinder by bringing a mark on the crosshead line on line with them, as in Fig. 184. This must be verified by moving crosshead and piston from one end to the other until the piston strikes the heads. If the piston rod has a threaded end, it should never be screwed into the crosshead with pipe tongs; that would leave deep and ineradicable marks on the rod and ruin it. A stout rope should be doubled and wound a sufficient number of times around the rod to give it a good hold, and a bar inserted in the loop; then, using the rod as fulcrum, it is comparatively easy to turn the piston rod. A piece of soft sheet copper inserted between bar and rod will protect the latter from getting bruised. The arrangement is shown in Fig. 185.

The common practice is to give Corliss engines from $\frac{1}{4}$- to $\frac{1}{2}$-in. clearance at each end of the cylinder. This is too much and results in a loss of steam. Besides, the faces of the pistons and cylinder heads are often not properly machined; in some engines they are left rough, with curved surfaces as shown in Fig. 186. The reason for all this, of course, is to cheapen the product. Large clearances and rough surfaces are detrimental to good steam economy. The loss through clearance and initial condensation often exceeds 25 per cent. of the total steam used. On many engines this could be reduced to 10 per cent., making a saving of 15 per cent.

Another continuous loss is caused by radiation; few cylinders are sufficiently protected against this loss. The ends of the cylinders, part of the steam chest and the rear cylinder-head flanges are often unprotected. On some engines the cylinder is incased in steel lagging, with a thin layer of insulating material covering the cylinder barrel and steam chest—an insufficient protection. Usually the cylinder heads are not covered. The space inside the lagging should be filled with 85 per cent. magnesia or asbestos and the heads covered likewise. Dead-air spaces give little protection from radiation.

The steam piping connecting boilers and engine must have ample provision for expansion and contraction: bends and elbows must be made to a long radius. Long and complicated steam pipes give poor economy. Natural drainage of the pipes is important; there should be no chance for water to collect in pockets. The principle of natural drainage is shown in Fig. 187. *A* shows valves

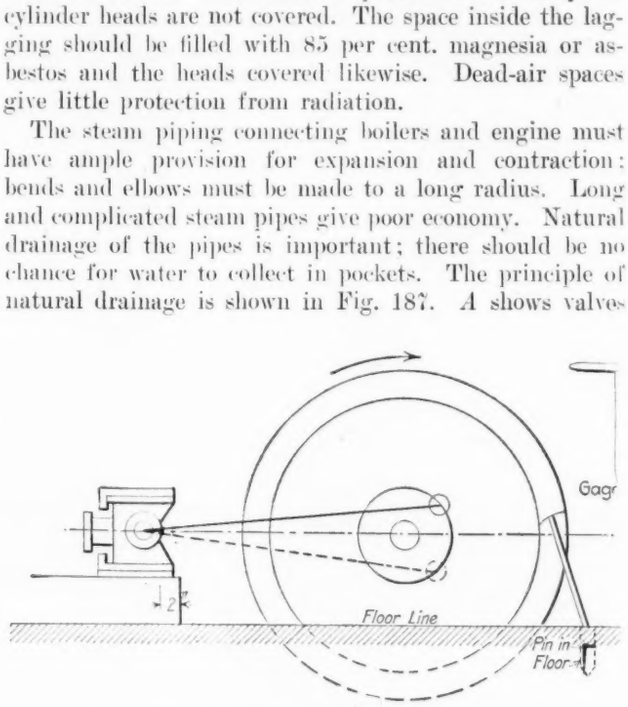


FIG. 190. LOCATING THE DEAD CENTERS

and pipes arranged correctly. Water condensed in the pipe will either run back to the boiler or toward the engine. If it collects over the engine, it will either be discharged through the drainpipe, which is usually opened to clear the pipe before the engine is started, or it will run into the cylinder and out through the exhaust when the cylinder is warmed before starting. While the engine is running and taking steam, no water can accumulate in the vertical pipe. View *B* shows the valve in an undesirable position near the boilers; there is a chance for water to collect over the valve when it is closed, and on opening this would be thrown toward the engine and would cause water-hammer. If the engine is connected to a steam main an arrangement similar to Fig. 188 should be used. In this no water can collect except over the engine, whence it will be drained, as stated before. In *B*, Fig. 188, water will collect in the pocket between the main and the valve and may cause trouble. To allow for expansion, loops or bends in the pipe should be placed in a horizontal position with a drop toward the engine. If more than one boiler furnishes steam to the engine, each should be provided with an automatic nonreturn stop valve that will close when the pressure in the main exceeds that in the boiler. A butterfly valve or an automatic stop valve should be placed in the steam pipe to be instantly closed from various parts in the engine room, by hand or by an automatic safety stop on the engine, if the speed is exceeded.

The steam pipes should be well supported by pipe hangers or brackets to relieve them of all strains due to their weight. Flanged joints should be used, with the

flanges either screwed on or welded to the pipe. All horizontal pipes should be pitched about 1 in. in 10 ft. for good drainage. The pipe line should be carefully tested by gradually increasing the steam pressure: it should never be exposed to the full pressure immediately after erection; it should be blown out before it is connected to the engine or to the separator. It is sometimes a revelation to note the things that have been deposited in the pipes; waste, wrenches, files, tobacco, bolts and gaskets are only a few of them. If any of this rubbish is allowed to reach the engine it will cause serious damage, perhaps a wreck. If a separator is located over the engine, it should be taken apart and cleaned a few days after an engine has been started.

In putting the connecting-rod in place it should be ascertained whether the crosshead pin and crankpin are in line and parallel. For this purpose the crank end of the rod without the boxes is slipped over the crankpin and the crosshead end attached to the crosshead and adjusted tight on the pin by pulling up the wedge. If the two pins are in line the distances A and B in Fig. 189 will be equal for any position of the crankpin and the sides of the slot in the rod will be parallel with the pin. The crankpin boxes should next be put in and adjusted and the dead centers of the crank located. To do this lay off a certain distance, say two or three inches, from the line on the guide which indicates the end of the stroke, as shown in Fig. 190, for the crank end. Make a gage 24 in. long, shown in detail, and secure a steel pin in the floor near the rim of the flywheel. Now revolve the wheel until the line on the crosshead coincides with the line 2 in. from the end of the stroke and mark the rim, using the gage set into a center-punch mark on the pin; then turn the wheel till the line on the crosshead on the return stroke again registers with the line on the guide and make another mark on the rim with the gage. In dividing the distance between two marks on the rim, a point is located which, when brought to the position in regard to the fixed point in the floor determined by the gage, will show that the crankpin is on the center at the crank end. The dead-center at the head end is established in a similar way.

To facilitate turning over the engine by hand, the flywheel should have holes cored or drilled in the rim for barring. On square-rim wheels holes 1½ to 2 in. diameter or square, according to the size of the wheel, spaced 6 in. from center to center, should be located in the face of the rim, as shown at A, Fig. 191, while on band and rope wheels they are drilled in one side or one of the return flanges is cast with teeth of about 4-in. pitch. Both these methods are shown at B and C. A simple cast-iron stand fastened on the floor near the rim will act as a fulcrum for the bar, or a pawl and lever supported by a stand on one side of the wheel may be used with the toothed rim.

Eccentrics are made solid or split according to the service for which the engine is intended. Split eccentrics are almost exclusively used on direct-connected engines. Corliss-engine eccentrics must not be keyed on the shaft, but should be provided with setscrews large enough to hold them securely in place without any danger of slipping. The bore should be recessed in the middle about $\frac{1}{16}$ in. deep, as shown in Fig. 192, to allow the eccentric to clear burrs on the shaft, made by forcing the hardened, cup-shaped end of the setscrews into its surface. The straps must have an easy fit on the eccentrics. There is no special advantage in having them babbitted except that when they run hot the babbitt will melt without scoring the eccentric. Cast iron on cast iron makes a good wearing surface if the lubrication is ample and the supply of oil is constant.

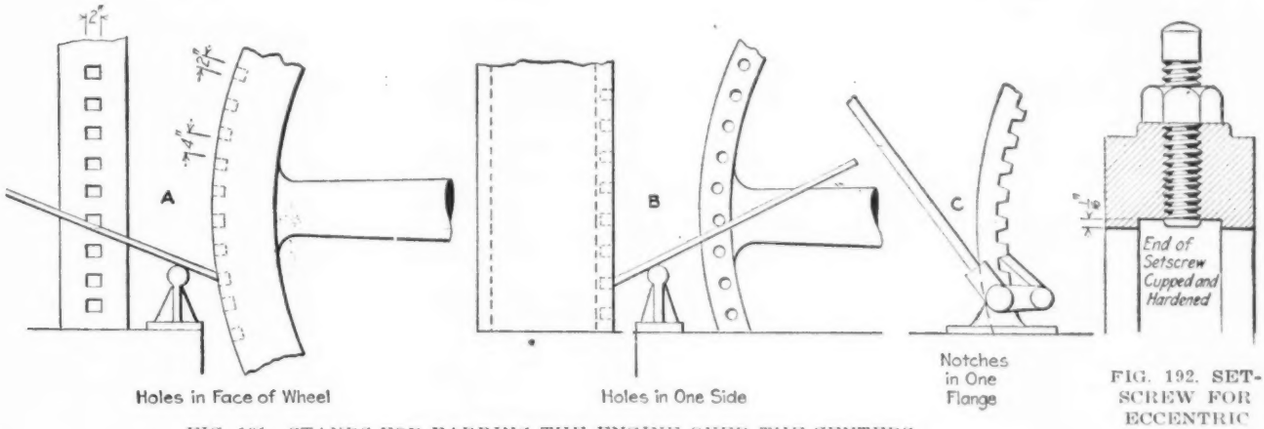


FIG. 191. STANDS FOR BARRING THE ENGINE OVER THE CENTERS

FIG. 192. SETSCREW FOR ECCENTRIC

[The next article will treat of things to be careful about when setting the valves of Corliss engines. Many interesting indicator kinks add to the value of this article. Before the series ends the author will have an excellent article on the testing and shipping of the Corliss engine.]

New Use of Graphite-Babbitt Bearings—The use of graphite inserts in babbitted bearings has been adopted by the Jeffrey Manufacturing Co., of Columbus, Ohio, for its power-transmission, conveying, elevating, crushing and screening equipment. This is reported to allow reduction in the amount of oil and to give improved service under the severe operating conditions and neglect to which this class of apparatus is subjected. The graphite cones are pressed in place on a fine copper screen that is inserted in the bearing boxes before the babbitt is poured.

Whitewash for Boiler-Room Walls or elsewhere is made of lime slaked with boiling water, keeping it covered during the process. Strain, and for each half-bushel of lime add a peck of salt dissolved in warm water, 3 lb. of ground rice put in boiling water and boiled to a thin paste, ½ lb. spanish whiting and 1 lb. clear glue dissolved in hot water. Mix well and let it stand for a week before using. Apply the whitewash hot to wood, brick, stone or concrete, and it will be found nearly as durable as paint. It may be colored to suit by adding cheap coloring matter.

Cooperation in Foreign Trade as Applied to the Power Industry

By Ludwig W. Schmidt

SYNOPSIS—An outline of the coöperative methods employed by European nations in securing foreign trade in the power industry.

The electrical industry in Europe has obtained its hold on the world's market by perfect coöperation of capital and industry. Also, individual firms have frequently cooperated with a view to obtaining orders in foreign countries, by such coöperation excluding from the field competing firms of other nations. The result of this policy of coöperation and mutual support can be noticed all over the world. It has created practically a monopoly for the electrical industry of one or the other countries in certain markets. By such methods the German electrical industry has gained a powerful hold on the Italian and Russian markets; the French industry has made it practically impossible for any other than French concerns to obtain business in several of her colonial possessions, and the great benefits obtained by the same method for the English electrical industry in many markets are also well known.

The fact that in consequence of the war foreign markets have bought more from this country than in former years has made necessary a closer study of the methods employed by the European electrical industry for the extension of foreign trade. The necessity of this study has led, among other things, to a closer observation of the cooperative methods employed. It has been shown that the commercial and industrial interests of the electrical-power industry of Europe are closely interwoven, and that this relationship is principally responsible for the great progress made by individual concerns in the development of their influence in power markets.

Control of Germany's Electrical Industries

The inter-relation of the German electrical industry was brought about by the increasing influence of two powerful groups of firms dominated in each case by a leading German concern, the latter having gained control over a great number of subsidiary enterprises. These two large concerns, by a slow policy of peaceful penetration, have been able to get under their leadership approximately 80 per cent. of the total electrical production of Germany. Most of the power plants in Germany are owned or financially dependent upon one of these groups. The control is now as complete as can be expected, the remaining free firms being mostly of minor importance for the electrical industry of Germany.

The free or forced coöperation of a great number of electrical enterprises has been supported also by German financial interests. The importance of this support may be readily realized by the fact that the total capital of the bank standing behind the two concerns is estimated to be approximately $850,000,000. Most of these banks are financial enterprises only. However, a number of them have been formed with the avowed purpose of giving financial support to the extension of the electrical industry of Germany. This purpose is well expressed in the name of these firms, among which we find the Bank for Electrical Enterprise, in Zurich, with a capital of $34,000,000, the Electrical Trust, with a capital of $13,200,000, and others.

Each of the foregoing groups is working separately, but in recent times they have also undertaken joint operation in a number of enterprises designed to increase the foreign influence of the German electrical industry, which in consequence of this close coöperation in foreign markets, has been able to enter agreements with leading firms in other countries, that have secured for that industry great benefits. It is most likely that such benefits could not have been obtained if bargaining had to be done individually.

Coöperation in European Countries

While the coöperative principle has not been carried to so great an extent as in Germany, nevertheless France and Belgium have frequently used this method for the improvement of their foreign trade. Belgium, by its help, was able to open a wide field for electrical enterprises in Russia. Also, by its assistance, French firms designed to finance foreign electrical industries have brought great benefit to the French electrical industry. The British electrical industry has also coöperated largely, for the purpose of obtaining foreign business. The electrical-power industry in England has found a very thorough support in the financial lending power of that country. It is estimated that the English investments in electrical power and tramway enterprises in South America alone represent nearly $650,000,000. Much of the capital invested in this way necessarily has been expended in English-made electrical machinery and equipment. The fact that many of the companies where British capital is invested are conducted from London secures for the English electrical industry a continuous flow of orders.

Benefits Obtained by Coöperative Methods

The great benefits obtained by coöperative methods in furthering foreign trade are generally recognized all over the world. The elimination of mutual competition in fields which would be too small for a number of concerns to work may be carried out in several ways. Coöperating firms have agreed not to erect power houses or to supply goods to territory that is already covered by another competing group, or which is conceded to such a group. Also, groups may agree to supply only certain material to one particular market, leaving it to the other group to supply the rest. It appears that methods like this are employed by the German concerns with regard to Turkey, where all the leading German electrical concerns are represented, having a working agreement limiting the field of each firm.

A form of coöperation in the foreign field also found in the electrical industry is that of coöperating in one particular market only. A good example for this kind of coöperation can be obtained in China. Most of the power plants in that country are built with the assistance of one of the different foreign electrical national groups working in China. The usual way seems to have been that pros-

pective promoters of electrical-power stations have obtained banking credits, the banks again giving these credits under the condition that at least part of the equipment was to be bought from the industrial concerns represented by the bank. The business in each case finally is transacted by the local coöperative agencies. It is an interesting fact in this connection that one of the largest coöperative agencies in China distributing electrical material and being interested in power development is representing not only German, but also English interests.

Coöperation in the form of foreign distributing companies as a rule takes place in such a way that a series of concerns not directly competing unite for a combined effort supported by a banking concern ready to finance the enterprise.

The latter is of special interest to American power interests as it shows one of the ways in which coöperation with capital can be obtained in the foreign field. Certain banking interests in Europe have made a specialty in financing the development of electrical-power enterprises. The large experience they collect in the course of their work and the wide connection they obtain through their financial activity give these banks a considerable influence in the field of electrical promotion and investing. They will in consequence gain control over a great number of power enterprises, adding frequently others to the list of their customers. How large this influence may be was shown during the present war, when Russia and other countries began to wind up the firms connected with citizens of the enemy countries. It then showed that a large part of the Russian electrical and power industry was practically directed by one huge banking house having directly or indirectly obtained a leading influence in many smaller Russian enterprises. The same firm also controlled many of the Italian electrical firms. Although this particular firm was located in a neutral country, the near relationship with German financial and industrial interests was assumed and the firms supported by this bank were practically all treated as enemy concerns.

Steam Engineer's License Examination

By H. F. Gauss

SYNOPSIS—The Corliss valve gear with directions for setting valves on single-eccentric and double-eccentric engines.

The distinctive feature of the Corliss valve gear is the means of securing cutoff, also the use of circular, oscillating, instead of flat, sliding valves. The terms lap, lead and angle of advance apply to the Corliss valve with the same meaning as they apply to the slide valve. However, the lap is measured when the eccentric and wristplate are in mid-position, and not when the valve is in mid-position. The ordinary single-eccentric valve gear consists of a wristplate pivoted at the middle of the cylinder. This wristplate is driven by the eccentric, through the eccentric rod, rocker arm and reach rod. On this wristplate are four pins, two steam and two exhaust pins. The valve chambers are bored across the entire width of the cylinder at right angles to the main cylinder bore and, looking at a side elevation, are located one at each of the four corners of the cylinder casting. These valve chambers are connected by means of short ports to the main cylinder bore and contain the valves, which are portions of cylindrical surfaces. The stems of these valves project out on the valve-gear side of the cylinder, passing through stuffing-boxes and supported by valve-stem bonnets. These stems carry the operating mechanism for the valves. Those for the steam valves, which are the upper two, consist of the steam arm, keyed rigidly to the valve stem and carrying the latch block; the steam bell-crank, one arm of which carries the latch and spring and the other the steam link pin; the knock-off cam disk, which also carries the safety cam, the position of this disk being controlled by the governor. The steam arm is drawn down by means of the dashpot, the rod of which is attached to the arm by means of a knuckle joint. The steam link connects the steam pin on the wristplate with the steam pin on the bell-crank arm. The exhaust link is connected directly to the exhaust arm, which in turn is keyed rigidly to the exhaust-valve stem without the intervention of the various other parts controlling the steam valve. Fig. 1 shows the gear as described. The illustration shows the valve motion side of a Corliss cylinder with all of the essential parts assembled.

To show exactly the function of each of the foregoing parts, Figs. 2, 3, 4 and 5 have been prepared in which a Corliss engine valve gear is shown in various positions,

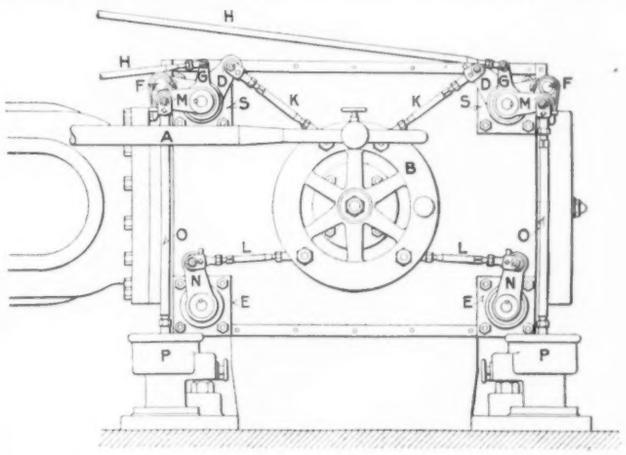


FIG. 1. VALVE GEAR OF FULTON CORLISS

A, reach rod; B, wristplate; K, steam link; L, exhaust link; D, steam bell-crank; M, steam arm; G, knock-off cam disk; F, steam latch; O, dashpot rod; P, dashpot; S, steam bonnet; E, exhaust bonnet; N, exhaust arm; H, governor rod

and the relative motions of the crank and eccentric together with the valves are indicated.

In Fig. 2 the engine is on the head-end center. Notice the lead to head-end admission and crank-end exhaust. Fig. 3 shows the engine at head-end cutoff. The steam valve is being pulled shut. No more steam will be admitted to the cylinder, and that already in will work expansively up to release. Fig. 4 shows the engine on the crank-end center. This is the other lead position. Notice the lead to the crank-end admission and head-end exhaust. Fig. 5 shows the engine with the valve gear in

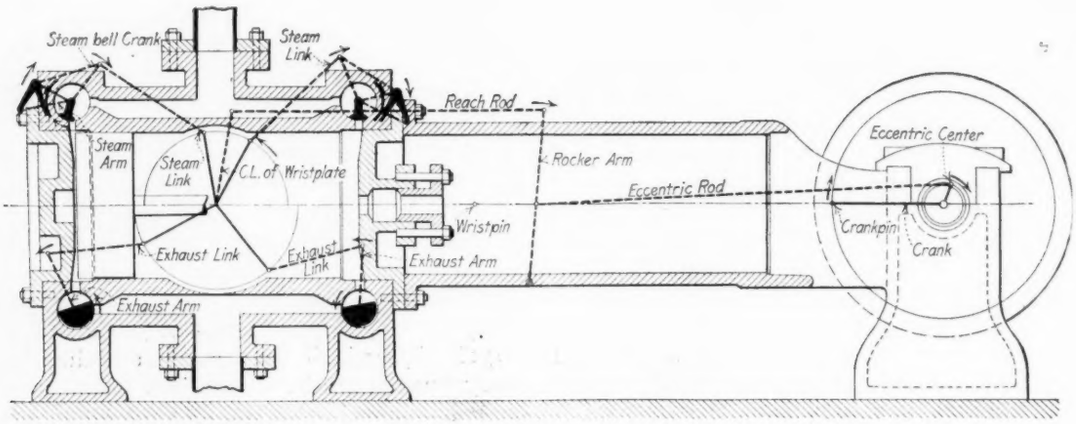


FIG. 2

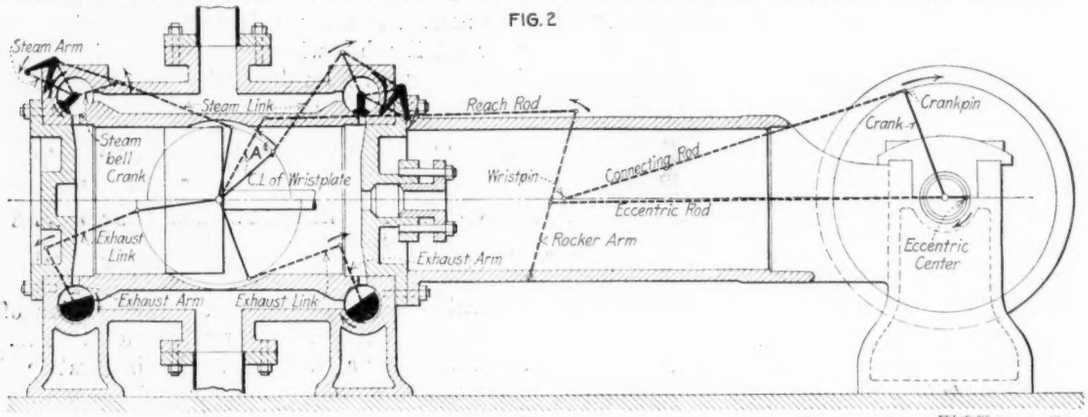


FIG. 3

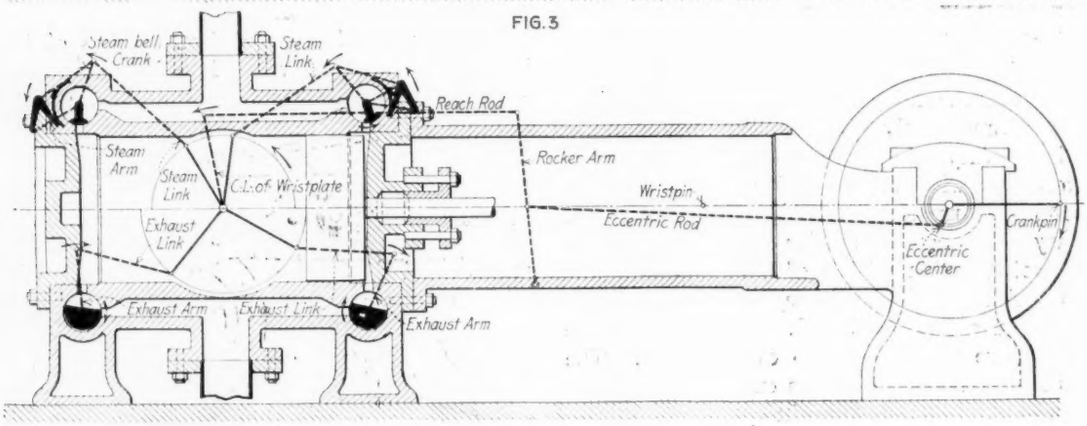


FIG. 4

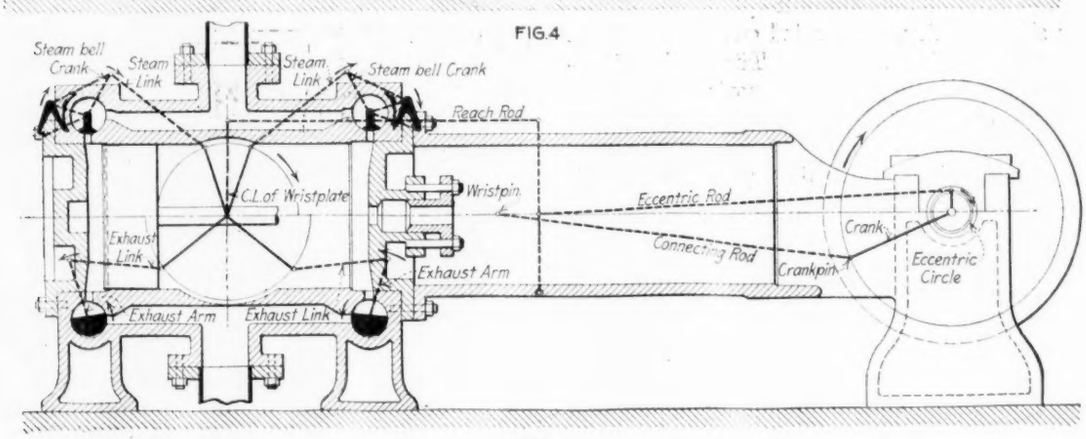


FIG. 5

FIGS. 2 TO 5. POSITION OF VALVES RELATIVE TO CRANKPIN

Fig. 2—Engine on head-end center. Fig. 3—Engine in position for latest cutoff at head end. Fig. 4—Engine on crank-end center. Fig. 5—Engine with valves in lap position

mid-position. The steam and exhaust ports are covered by the steam and exhaust laps respectively, except the head-end steam port, which is covered by the seal. In all cases the arrows indicate the direction in which the various parts are moving.

By studying the figures it becomes clear that unless the knock-off cam causes the latch to release the steam arm before the eccentric reaches its maximum displacement, it will not cause release at all, and the steam valve will be closed positively by the valve gear, steam being admitted to the cylinder throughout the entire stroke. Hence with a single-eccentric Corliss engine, the latest point at which cutoff can occur is at one-half stroke with an angular advance of zero. The usual point of cutoff corresponding to full load, however, is at three-eighths stroke. This is due to the fact that the exhaust and steam functions are controlled by the same eccentric and it is impossible to vary one without affecting the other. Any attempt to secure cutoff later than at one-half stroke by using a negative angle of advance so retards the action of the exhaust functions that it becomes prohibitive.

By carefully analyzing the operations of the various parts, the setting of the valves in single-eccentric Corliss engines becomes a simple operation. The function of the rocker arm is to multiply the motion produced by the eccentric, as well as to make it possible to use a short eccentric rod and to support the ends of the eccentric rod

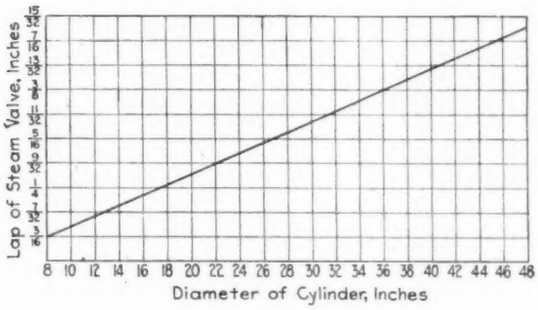


FIG. 6. STEAM LAP FOR VARIOUS CYLINDER SIZES

and reach rod. To properly transmit the motion of the eccentric to the wristplate, it is essential that the rocker arm vibrate equal distances to either side of the vertical center line. This is tested and secured by suspending a plumb-line so that it hangs through the centers of the rocker-arm pivot and revolving the eccentric around the shaft or turning the engine over. If the rocker arm pins swing through equal arcs to either side of the plumb-line, it is properly set, but if it does not, the eccentric rod must be lengthened or shortened, as the case requires.

The motion of the rocker arm is transmitted to the wristplate by means of the reach rod. It is desirable that the reach rod be horizontal in its central position, hence the wristplate should vibrate through equal distances to either side of its central position. This is secured by proceeding in the same manner as in the case of the rocker arm. The adjustment here, however, is made by lengthening or shortening the reach rod. Generally the hub of the wristplate is provided with a mark so placed as to register with three marks on the boss around the wristplate pivot. These marks on the boss are so located that when the mark on the hub is opposite the central mark on the boss, the wristplate is exactly in midposition, and at either extreme the mark on the hub coincides with one of the others on the boss. This obviates the necessity of using a plumb-line. For instance, in Fig. 7 *b* is the mark on the hub of the wristplate, while *ncn* are the marks on the pivot boss, *c* being the center mark and *nn* the extremes.

With the rocker arm and wristplate in mid-position the steam and exhaust ports should be covered by their respective laps. The proper steam lap varies from $\frac{3}{16}$ in.

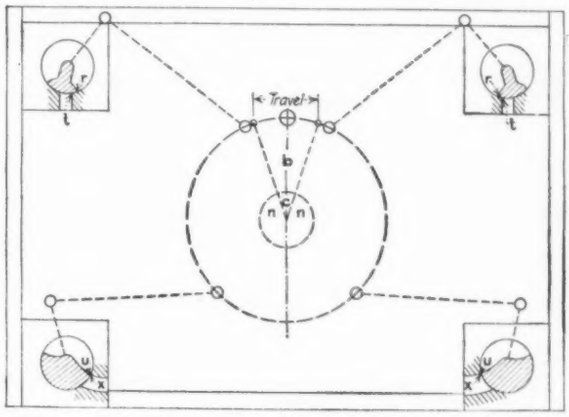


FIG. 7. MARKS TO FACILITATE VALVE SETTING

for 8-in. cylinders to $\frac{3}{8}$ in. for 36-in. cylinders. Fig. 6 is a plot by means of which the proper steam lap for intermediate sizes of cylinders can be determined.

As regards the lap to be used with the exhaust valves, opinions differ. It is customary to set the exhaust valves with zero lap—that is, line and line—and when this is done, compression and release for opposite ends of the cylinder take place simultaneously. An examination of the indicator diagram is the best means of determining whether the valves have been set with what may be considered proper lap; slight changes must be made before a well-proportioned diagram can be obtained. These adjustments are to be made by altering the lengths of the

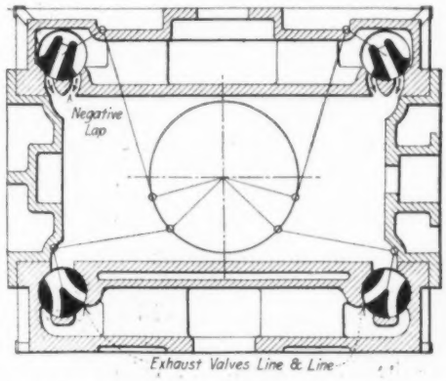


FIG. 8. VALVES IN LAP POSITION, DOUBLE-ECCENTRIC ENGINE

links, which are provided with sleeves and locknuts for that purpose. To facilitate the adjustment of the lap and lead, the working edges of both steam and exhaust valves are marked with lines on the ends of the valves and likewise the working edges of the ports are projected to the face of the valve chambers and marked. In Fig. 7 *u* on the end of each exhaust valve coincides with the working edge of the valve and the *x* on the face of each exhaust-valve chamber coincides with the working edge of the port. These lines can be seen by removing the

rear caps from the valve chambers. In case they are not shown, the first operation in setting the valves is to carefully locate and mark them.

The next step is to set the eccentric with an angle of advance sufficient to give the proper lead, which, as already stated, for steam valves varies from $\frac{1}{32}$ in. for 8-in. cylinders to $\frac{1}{8}$ in. for 48-in. cylinders. For engines in which the rocker arm merely multiplies the motion of the eccentric, set the eccentric 90 deg. plus the angular advance ahead of the crank. For engines in which the rocker arm reverses the motion of the eccentric, set the eccentric 90 deg. minus the angle of advance behind the crank. Again it may be said that the proper final location

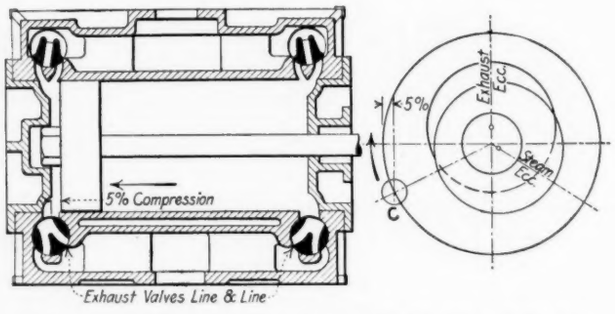


FIG. 9. DOUBLE-ECCENTRIC ENGINE AT POINT OF COMPRESSION

of the eccentric is to be determined by the indicator diagram, as a change in the lap will also affect the lead with a fixed angle of advance.

The next step is to adjust the length of the governor reach rod so cutoff will occur at the proper point. To secure this, place the engine in the position at which it is desired to have cutoff occur, and with the governor blocked up to normal running position, adjust the length of the governor reach rod so that the knock-off cam will cause the latch to release the block on the steam arm at this point. The operation must be repeated for the opposite end of the cylinder. Owing to the obliquity of the connecting-rod, the percentages of the stroke for the points of latest cutoff are different for the two ends. Latest cutoff in the head end occurs considerably later than latest cutoff in the crank end.

Some Corliss engines are designed so that the steam bell-crank has "pull back"; that is, so that the steam pin goes appreciably past the radial position of the steam link, causing the bell-crank to return a slight amount and retreat again, before finally picking up the steam arm. The amount of pull back permissible is limited by the latch clearance, as the latch must not be allowed to strike the block twice. The latch clearance is also limited by the fact that the steam bell-crank must not be allowed to acquire velocity enough, before the latch engages, to cause the latch to strike the block a blow. The proper clearance is secured by altering the length of the dashpot rod, and care must be taken to see that with the rod in its lowest position, the port is covered with the proper seal to prevent leakage of steam past the valves.

In Fig. 5, which shows the engine in the lap position, the latch on the steam arm of the head-end valve was purposely left released, and the valve is shown in its lowest position, covering the port by the seal. This seal should be about one thirty-second of the cylinder bore. In this position of the valve the cutoff edge of the port is covered by the lap plus the distance the valve must move before the mid-position of the wristplate is reached, which together make the seal on this side of the port. This seal is generally greater than necessary to prevent leakage, but is controlled by other conditions of design and cannot be altered. Of course, for the adjustment of the dashpot rods, it is not necessary to roll the engine over; but the reach rod can be unshipped and the valves worked with the starting bar.

In the preceding it was stated that the latest point at which cutoff could occur in a single-eccentric engine was at one-half stroke with an angular advance of zero. By employing separate eccentrics, however, for the steam and exhaust functions, the exhaust valves operate entirely independently of the steam valves, and the steam eccentric can be set with any desired angle of advance without affecting the exhaust at all. It may be stated here, however, that a cutoff later than at seven-tenths stroke is poor practice from an economical standpoint.

The procedure for setting the valves on a double-eccentric Corliss engine is identical with that for a single-eccentric engine. The steam and exhaust valves are entirely independent. The exhaust valves are set in exactly the same manner as in the case of the single-eccentric engine—with either zero lap or a small positive lap.

The steam valves, however, are set with a negative lap; that is, the port is open when the wristplate is in mid-position. This necessitates a negative angle of advance for the eccentric to prevent an excessive lead. Very often the steam pins are located below the horizontal center line of the wristplate, thus reversing the motion of the valves. Accordingly, instead of setting the eccentric 90 deg. plus the (negative) angle of advance ahead of the crank, it is set 90 deg. minus the (negative) angle of advance behind it. Fig. 8 is a diagram of the valve gear on a double-eccentric Corliss engine, showing the valves in the lap position, that is, with the wristplates in mid-position. Notice the negative lap of the steam valve while the exhaust valves are line-and-line.

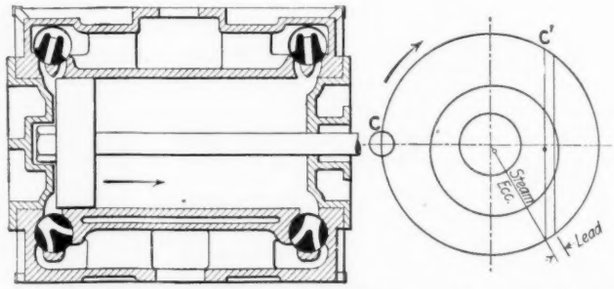


FIG. 10. DOUBLE-ECCENTRIC ENGINE IN LEAD POSITION

Fig. 9 shows the same engine at the point of compression and also shows the relative position of the crank and eccentrics. Notice that the steam eccentric is 90 deg. minus the (negative) angle of advance behind the crank. Since minus a minus equals a plus, the resulting angle between the steam eccentric and the crank is greater than 90 deg. Fig. 10 shows the engine in the lead position.

Evidently, unless the engineer is thoroughly familiar with an engine or can secure working drawings, considerable care and experimenting may be necessary before the most economical and satisfactory setting of the valves can be obtained.

Editorials

Coöperation in Foreign Trade

From time to time there have been published in these columns various articles dealing with different phases of the power industry in foreign countries and calling attention to the necessity of America doing her part to obtain a just share of the trade in these markets. We again call attention to an article elsewhere in this issue on "Coöperation in Foreign Trade as Applied to the Power Industry." If there is one question more vital than another in securing foreign trade, it is the coöperation of the various American financial and manufacturing interests to this end.

The American power industry so far has been prevented from employing the principle of industrial and financial coöperation in the development of its foreign trade. Popular sentiment and resulting laws have excluded the industry from any possibility of combating the business methods recognized by the laws of other countries, and this no doubt has acted as a severe handicap to our own industry. Now it seems to be generally realized that this handicap will have to be removed, and steps have been taken for that purpose.

It has been pointed out in previous articles and also in this one that the orders for power equipment nearly always go to the country that furnished the capital. Any effective coöperation of manufacturers seeking to use methods similar to those employed in the building up of the foreign trade of the European electrical-power industry will have to seek also the coöperation of capital.

American capital in recent years has taken a considerable interest in the development of public utilities and the electrical-power industry in this country and has greatly benefited in consequence. The good results obtained by investors supporting the American power industry should lead investors also to consider the possibilities of investment in foreign power developments. It is certain that no permanent relationship can be obtained with the foreign market unless part of the development work is also done by this country. Not only will foreign countries expect such a financial support, but the fact that other countries competing abroad with the American electrical-power industry are willing to give it makes it practically imperative for the American power industry to make the same concession.

The same applies to the principle of coöperation in general. It may be conceded that fairly good results have been already obtained with the present not coöperative methods. These results, however, have been gained against a strong competition favored in each case by a strong organization and working under the best possible conditions. After the war the foreign organizations will work with an increased activity. To leave the American power industry unprotected against this possibility, or to deny her the means for securing her well-deserved position abroad, not only might decrease the rate of progress made but even might endanger that which has been obtained in former years.

Smoke Abatement at Boston

In spite of adverse fuel conditions, the attempted observance of the Boston smoke law during the fiscal year 1916 was general, according to a report of the Massachusetts Gas and Electric Light Commission recently submitted to the Legislature. During no other year since the present smoke law went into effect in Greater Boston have conditions been so uncertain, so confusing or so far-reaching. At the opening of the calendar year the fuel situation in Boston became serious, and for three months the weather conditions and the railroad congestion combined to keep matters in a critical state. Manufacturers and users of steam had to use such coal as they could get, and during this period plants that had ordinarily operated without objectionable smoke became offenders temporarily, or until they were able to procure their regular grade of coal. Moreover, the labor situation in many of the stationary plants and on the railroads became and still is acute. Many operators have found it impossible to keep or even get good firemen.

In common with all other sections, the industrial activities of the Boston district have been keyed up to the maximum, so that boilers have been forced and old ones have been called into service again without being equipped for smokeless operation. The cost of fuel has increased, and more of the higher-volatile coals have come into the market. These factors will ultimately work for smoke abatement, the commission states, as the purchaser will realize the need of obtaining all the heat units contained in the coal and will insist on proper firing and on equipment that will give the maximum efficiency. Notwithstanding all these conditions, which have a tendency to increase rather than to diminish the emission of smoke, the commission feels that progress has been made.

During the year a new plan for recording the observations taken in the various sections of the district was devised and put into operation by Inspector Edson. It has resulted in making the periodic examinations more thorough and systematic. The plan consists of dividing the district into sections and keeping a record of all inspections in each section by date and inspector, so that the history of all inspections can be determined at a single glance from a tabulation on file at the office of the board. But one public hearing was required during the year. Fifty complaints were lodged with the commission. No prosecutions were required. A total of 79,829 observations was made, compared with 35,424 in 1913, the first year of the smoke law's application. Stationary stacks accounted for 60,243 observations, and in 704 cases the observation of the stationary stacks showed smoke emission in excess of the legal allowance. The percentage of observations in which violations were found has fallen from 3.3 to 1.2 for stationary stacks in the four years. At the close of the fiscal year, November 30, all public-service stacks observed had complied with the law, but eight manufacturing-plant stacks and one office-building stack were still emitting excessive smoke.

Commutators and Brushes

If the quantity of literature published about a device is a criterion of its importance in the evolution of an art, then the commutators and brushes of direct-current machines are preëminently the most significant factors in the development of the electrical industry. The one subject in reference to electrical machinery that has been discussed more than any other is this, and attention is again called to it in the article on "Commutators and Brushes" in another part of this issue.

To prevent sparking at the commutator and brushes was one of the earliest problems to be solved, and this was a difficult one with the copper brushes used on the pioneer machines. A long step forward in the art was taken when the carbon brush was introduced. The one element that has had the greatest influence in the evolution of the direct-current machine has been the carbon brush, and it goes without comment that the present high development of electrical machinery was made possible only by this type of brush in its varied qualities. Nevertheless, radical changes in the design of the machine have had to be made to obtain perfect commutation, such as the introduction of interpoles, compensating windings, using the proper grade and thickness of mica insulation between the bars, and slotting the mica from between the bars of the commutator. In recent years the brush manufacturers have taken an active part and their engineers have developed brushes suited individually to almost every condition; consequently it is no longer a universal brush for all conditions, but a special one for each condition, with a marked improvement in operation.

Although the commutator has been the one and only thing that made possible the commercial direct-current machine, nevertheless it has always been one of the designing and operating engineer's sources of worriment. The development of electrical machinery without a commutator that would satisfactorily meet all the needs of the multiplicity of power application has long been the dream of many an electrical engineer. The squirrel-cage type of induction motor at first gave promise of accomplishing this end. Its construction is ideal, but it is inherently a constant-speed machine, unless of special construction, and even then it cannot be compared, as to operating characteristics, with the direct-current shunt motor. Consequently this type of equipment cannot be efficiently used in many applications; therefore where wide variation and close adjustment of speeds are required, we must rely upon the direct-current machine with a commutator.

Many attempts have been made to construct a commercial direct-current machine without a commutator, but up to the present time none has been produced with operating characteristics that could be compared with those of the commutator-type machine.

It is not alone in the development of the direct-current machine that the commutator has taken a significant part. In recent years its use has found an ever-increasing application in alternating-current motors. The most satisfactory single-phase motor so far developed utilizes a commutator on the rotor, and each year sees other manufacturers added to the list of those who have turned their attention to the construction of machines of this type. To increase the field of application of the polyphase alternating-current motor, manufacturers are turning to the development of polyphase commutator-type machines. As first produced, this type possessed the characteristics of a series machine, which naturally limited its application; but the recent announcement that a polyphase commutator-type alternating-current motor has been developed with a speed variation of one to four and other very satisfactory operating characteristics would indicate that the commutator is taking on a new lease of life and is destined to have a greater influence in the application of electricity than ever before.

⁂

Value of Visits to Plants

Some time ago the editor was standing in the lobby of a hotel in western New York. The day was done, as much as it ever can be for an editor, and he lingered among the seated and passing travelers hoping to see some acquaintance who would join him at dinner. The party came. He was a mechanical engineer with one of the large central stations, who had been on a trip far into the Middle West for the sole purpose of visiting plants, learning the successes and failures here and there that he might apply the lessons in the plants of his company. The trip paid many times over.

The lesson is this: If central stations find it worth while, with the many channels of information at their command, to send men out on long trips visiting plants for the knowledge gained, how much more urgent, how valuable, to engineers of isolated plants are visits of this kind. This is particularly true in the great industrial centers, where in a man's own city there is enough to keep him busy visiting for months.

Brooklyn No. 8, National Association of Stationary Engineers, is to be congratulated upon the many excellent visits that Chairman McGowan of its educational committee has arranged for and made this season. Here is a fruitful field for association work, and engineers should be only too glad to take advantage of such visits.

⁂

Most commendable is the action of the large copper mining and smelting interests in announcing through the Council of National Defense that the copper needed for the army and the navy will be furnished at a price representing the average for the past ten years. Considering the prices at which copper has been selling during the past two years and, on the other hand, the increased cost of production due to higher wages, this step is a sign of patriotic obligation that may well be emulated by other producing interests.

⁂

The president of a public-service corporation protests with vehemence against any further "crowding" on the part of the Public Utility Commission on account of the increased price of fuel. To those who know that the station cost of putting a kilowatt-hour on the switchboard is less than a cent while the charge to the consumer is ten cents, the vehemence is somewhat forced.

⁂

Those who have been bemoaning the decline of the large gas engine will find much to revive their hopes in the leading article of this issue which tells of the big work being done at the Sparrows Point plant of the Bethlehem Steel Co.

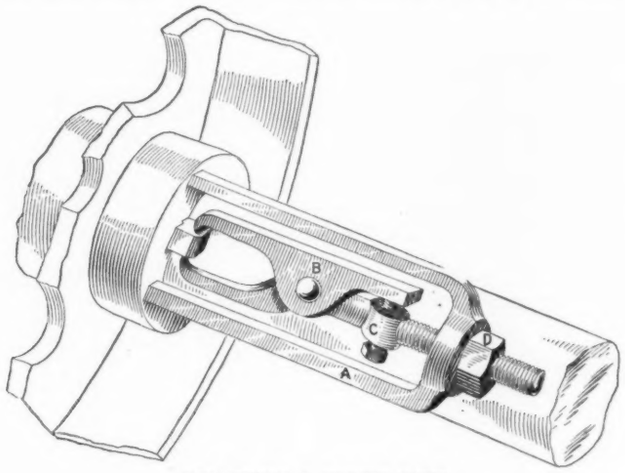
⁂

The latest converts to the A. S. M. E. Boiler Code are the municipalities of St. Louis and Kansas City, Mo.

Correspondence

Device for Drawing Tight Keys

The illustration shows a device especially designed for removing keys that are tight and inaccessible from the inner side of the pulley, as frequently found on line-shafts, electric motors, etc. The apparatus consists of a U-shaped forged bracket *A* lying close to the shaft, toward the key, and pressing against the boss of the pulley. After



DRAWING A TIGHT KEY

making a "nick" with a cold chisel, as conditions demand, the tongues *B* are placed so as to grip the key by means of the setscrew *C*. Finally, by the aid of a wrench on nut *D*, *A* is forced against the boss of the pulley and the key is drawn out. A 1-in. machine screw with an extra-wide nut will answer in most cases.

Louisville, Ky. EMILE PILPEL.

Horsepower of Our Battle Cruisers

In your editorial on "The Horsepower of Our Battle Cruisers" on page 29, of the Feb. 27 issue, you state that the arguments are divided between the advocates of electric drive and reduction gearing and that it would doubtless seem that the electric drive should present no greater difficulties than have been successfully handled in many of our large power plants. In fact, you go on to say that the Navy Department would do well to seek the advice of some of our well-known central-station engineers, both as to design and operation of these huge electric plants on shipboard.

In the first place, as the writer understands it, it is not a question as to whether the electric drive or the reduction-gear drive will work out satisfactorily, but it is a question, and a very important one, as to whether the boilers should be located in a place where they are accessible to the shells of the enemy. With the reduction-gear drive the boilers can be placed below the protective deck, which is approximately the water line of the vessel, while with the electric drive some of the boilers have to be placed above the water line and consequently are subject to damage by gunfire.

Even though a battle cruiser had three-quarters of the power required to operate the combined subway and elevated in New York City during rush hours and still did not have sufficient to get away from a superior force, it would avail nothing. You either must have, as the writer believes, quality or quantity, and certainly we are not able to get quantity. A few battle cruisers that can move in and out of the zone of fire without damage to themselves is the most important need with our limited navy. Battleships get obsolete soon enough, and anything that is built should at least be a step forward, and we should not be content with the average.

Cleveland, Ohio. S. R. SAGUE.

Disapproves Telescopic Oilers

I am inclined to disagree with Mr. Fenno on page 326 in the issue of Mar. 6 and to agree with Mr. Hamkens in his article on page 142, Jan. 30, in regard to telescopic oilers for crosshead pins, as I have two such oilers that have been installed only a short time, and compared to wipers they are failures. These oilers are reducing motions and oilers combined. If as much oil is used as with the wipers, the oilers will "cover the floor." Any information I can get as to how to overcome the pumping effect of the oilers will be appreciated.

Ninety Six, S. C. J. B. WALKER.

Do Blowers Cause Clinkers?

In the issue of Feb. 13, page 229, H. G. Gibson asks if the use of undergrate blowers will cause fires to clinker. I am inclined to think they will from the following experience: On a Lake George steamer, during the last summer, forced draft from undergrate blowers was used most of the time and the fires were almost always badly clinkered at the end of a trip. Some days, however, when forced to run slowly on account of fog, etc., the boilers would steam fast enough on natural draft, as the demand for steam was light and the blowers were not used, and on these days the fires were always free from clinkers. We burned buckwheat and pea coal, but I believe the results would be the same with any coal, hard or soft.

Keeping water in the ashpit will stop a good deal of the clinkering. It would also be a good plan to try to stop the exhaust steam from going in with the air for awhile and note the effect on the fires. I would like to hear on this subject from others who have had experience.

Delanson, N. Y. W. P. HUMPHREY.

The clinker complained of by Mr. Gibson is probably due to the use of the blowers (unless a different coal was used), but is no reflection on the blower because the clinker is in reality the result of a hotter furnace and not of the mixture of steam with the air entering the ashpit. As a matter of fact the use of steam is recommended by many stoker manufacturers as an aid in

reducing clinker trouble. In one of our new installations there is a steam pipe at each side of the furnace to "soften" the clinker and make its removal from the side wall easier.

The fusion point of ash varies from 2000 to 2500 deg. F., depending upon its original composition and the method of handling when at or near its fusion temperature. The melting point of substances or mixtures can be changed by the addition of other substances. In blast-furnace operation limestone is the element introduced to cause slag to form and carry away the impurities in a molten state. In boiler-furnace construction care must be used in the selection of the brick, particularly those which are to be placed in the side walls in contact with the hot fuel bed. Some kinds of brick not only have a low melting temperature, but the combination of certain elements in the brick with those in the coal gives still lower melting point, causing the clinker to fuse on the wall and the brick to waste away. The presence of an overheated firing tool in the fire may cause the same action.

As already mentioned, the method of handling the fires is responsible for much of the trouble. Two factors that must be recognized are: First, as the upper surface of the fire bed is the hottest part, as far as possible the ash should not be worked to the surface where it will be subjected to the high temperature; second, and by far the more important, more trouble is experienced when the ash is allowed to accumulate. When forcing fires with undergrate blowers, it is important that the ash be disposed of frequently, or on those types of stokers that have a continuous ash-discharging mechanism it should be discharged as fast as made.

As stated in the beginning, the blowers are the indirect cause of the clinker, but they give a greater steam-generating capacity and increase the boiler efficiency, owing to higher furnace temperature and a better fuel bed; so it is not quite fair to charge the clinker formation entirely against them, when it is partly chargeable to the method of handling the fires, partly to the grade of coal used and largely to the high furnace temperature.

We have more than twenty blowers in use and find that they more than double the boiler capacity and give remarkably high boiler efficiencies and at least 2 per cent. better CO_2.

J. C. Hobbs.

Pittsburgh, Penn.

Clinker trouble can be reduced if not entirely remedied by regulating the speed of the blowers so that they will not be entirely stopped long at a time, waiting for the steam to drop—kept continually forcing some cool air through the grates, thereby cooling them and the clinkers which have in the meantime been melting on and through the grates. Clinker is melted ash, and the highest temperature in the ash strata occurs for a short time after the blower stops.

With the induced draft, when the fan is stopped, some air finds its way through to keep the grates and the ash on them relatively cool, but with the undergrate fan the ashpit doors are fitted quite tight to prevent the loss of air, so when the fan is stopped very little air gets to the grates, consequently the heat from the fuel bed gets down to the ash and grate and sometimes melts both. This trouble is aggravated if the fan is run at full speed and then stopped altogether.

From the foregoing the reader might think I was knocking the undergrate blower, but not so, as the faults mentioned are easily remedied and I believe an individual blower applied to each boiler is ideal and that eventually, no matter how large the boiler may be, the individual turbine will be installed with each boiler.

Somerville, Mass. John M. Coleman.

Truck Assists in Cleaning Condenser Tubes

In the tubes of our ammonia condensers salt water is used, and this water is very dirty—so dirty and salty, in fact, that it is practically impossible to push a steel brush through the tubes to clean them. To assist the

ELECTRIC TRUCK CLEANING CONDENSER PIPES

operating force in this work, a small electric truck obtained from the shipping department had bolted on it an upright of heavy planking, which is seen in the illustration. The plank was 7 ft. high and 10 in. wide and served as a place of support for the $\frac{3}{4}$-in. pipe on the end of which was the brush used for cleaning the tubes. In cleaning the tube the brush is inserted in the end of the tube and, with a man holding the pipe to guide it, the electric truck is used to push the brush through the tube, also to pull it out. One end of the pipe is provided with

an extra-heavy elbow and nipple, around which a rope may be fastened so that the truck may withdraw the pipe or brush.

GEORGE W. LEE.

New York City.

The Schmidt Market Ammonia Explosion

In an article in *Power*[1], relative to the various recent explosions in refrigerating plants, it has been stated or assumed that the intermittent absorption machine in the market of Martin Schmidt, 339 Macon St., Brooklyn, which exploded last July, was equipped with automatic devices so that it had been presumed to be entirely safe. Unless there had been a change of construction in the preceding three years, the apparatus had no automatic or safety devices of any kind. I made a careful examination of this plant in the summer of 1913, after it had been installed for several years, and perhaps can now discuss this particular accident with a fair degree of confidence. The purpose will be to determine generally the cause of the explosion and to show how easily it might have been averted by providing certain safeguards.

The Schmidt machine had its operative parts located in the basement under the main part of the market, and consisted of the following simple elements: A horizontal generator about two feet in diameter and about eight feet long, with a fuel-gas heater underneath extending along its entire length and so inclosed and insulated as to prevent, as much as possible, the radiation of heat. Within the generator there was a descending cooling-water coil, discharging into the sewer. The receiver was a horizontal cylinder somewhat smaller than the generator. The condenser, attached to a side wall, was of the counter-current, double-pipe type, six pipes high, and discharged into the top of the receiver. A rectifier, consisting of an inner pipe for water and an outer pipe inclosing the inner pipe so as to form an annular gas passage, was inclined slightly so that water, flowing upward from the condenser, entering the upper end of the inner pipe and thence flowing away to the sewer, would precool the hot ammonia gas ascending from the generator, before it entered the top of the condenser. The expansion coils refrigerated the usual boxes on the main floor of the market and terminated in a pipe discharging into the lower part of the generator. The system was controlled throughout by hand-operated valves.

MANIPULATION OF THE PLANT

In running the plant the operator was in the habit of starting the active period of refrigeration, otherwise called the absorption period, in the late afternoon. To this end he performed three acts: He opened, slightly, the expansion valve in the pipe line from the receiver; opened a valve at the outlet end of the expansion coil, just outside of the generator; and opened a three-way valve controlling the inlet end of the water-cooling coil in the generator. At this time the receiver, as indicated by a liquid level gage, would be about two-thirds or three-quarters full of liquid ammonia. The generator pressure would be about 25 in. of vacuum. The ammonia from the expansion valve, vaporizing in the expansion coil and rushing into the generator, gave up its heat to the absorbent water, partly filling the generator, with a tendency to increase both the temperature and the pressure in the generator. But the water, flowing through the cooling coil of the generator, took away this heat of absorption so as to maintain a temperature of about 90 deg. and to prevent more than a gradual rise of pressure in the generator. This period of active refrigeration continued throughout the night, say for about fifteen hours. At the end, in the summer season, the pressure gage indicated about 30 lb. pressure in the generator. The system was so charged that some liquid ammonia would still remain in the receiver, although the absorption period should continue to some higher pressure limit.

The next morning the operator, in terminating the period of active refrigeration and in starting the heating period, had to follow this program: (1) Close the expansion valve. (2) Close the valve at the outlet end of the expansion coil. (3) Turn the three-way valve so as to prevent a flow of water through the cooling coil of the generator and to permit a flow of cooling water through the condenser and rectifier. (4) Open a valve controlling the flow of ammonia gas from the generator through the rectifier into the condenser. (5) Turn on and light the fuel gas. Very soon, as the strong solution became heated, ammonia gas separated from the absorbent water and, passing upward through the rectifier, condensed and flowed as a liquid into the receiver. A head pressure, maintained at about 160 lb., prevented the vaporization of the mass of absorbent water. Any particles of water entrained upward with the hot ammonia gas condensed in the rectifier and flowed back into the generator. This heating period continued from four to six hours, until the temperature in the generator, as indicated by a thermometer connected therewith, rose, say, to between 275 and 300 degrees.

HOW HEAD PRESSURE WAS DECREASED

When such a temperature was observed, the operator first turned off the fuel gas, closed the valve controlling the flow of ammonia gas from the generator and turned the three-way valve so that water no longer flowed through the condenser. The generator was then allowed to cool down, while the gage indicated a drop of pressure from 160 lb. to considerably less than atmospheric. The cycle of operation being thus complete, the operator could at any time start a second period of active refrigeration.

As I recall it, the boxes remained so cold over Sunday as not to require an intervening heating period. In cooler weather, it was said, the heatings took place every other day or every three days. For as the gage pressure, in the cooler season, while absorption was in process, did not rise to 30 lb., the absorbent water in the generator did not reach the economical saturation limit in a run of merely one or two days. The proprietor was fully aware that, during the heating period, the gage on the generator had to be carefully watched, so that in case of an interruption of the water supply and a rise of the condenser pressure the heating should be stopped. He volunteered the suggestion that it would be a good idea to have the gage located behind the counter, where it could be easily observed without someone having to make a trip to the basement every once in a while in the busy part of the day.

From this description it is apparent that the machine, if it may be called such, was simple and inexpensive in the extreme. It was also exceedingly economical to

[1] "Power," Oct. 31, 1916, second paragraph, first column.

operate. There were no troubles from lubricating oil. The vaporizing ammonia was dry. The little water that might escape over from the rectifier settled to the bottom of the receiver. Between the receiver and the generator there was a small pipe controlled by one valve near the receiver and a second valve near the generator. Occasionally, after a heating the operator would open the second valve and crack the first valve. In half a minute or so, on the appearance of frost, he would close the valves in reverse order. By this means the absorbent water was kept in the generator without depletion. The system being hermetically sealed, no atmospheric oxygen could enter to cause corrosion. Neither in this plant nor in others of the same make observed in that same summer could I see or obtain any history of troubles from foul gases.

Possible Causes of the Explosion

It is first to be noted that no accident consequent upon the operation of the plant could occur during the period of active refrigeration. For suppose the flow of water through the cooling coil of the generator should cease during such time, the temperature and presure in the generator would thereupon gradually rise until such pressure equaled the pressure in the receiver. Then the apparatus would become stalled, so that, except in so far as a very slight heat radiation from the surface of the generator would permit, ammonia could no longer pass the expansion valve.

The accident of July 13, 1916, in the Schmidt plant, occurred in the middle of the forenoon. From the preceding analysis of the construction of the plant, combined with matters of common knowledge on such subjects, it is certain that the explosion resulted from one of these three causes: (1) Neglect, at the starting of the heating period, to open the valve controlling the ammonia gas passage from the generator into the condenser; (2) neglect, at the starting of the heating period, to turn the three-way valve so as to prevent a flow of cooling water through the generator and to permit such flow through the condenser; (3) a failure of the flow of condensing water from the street mains, occurring with the latter valve in proper position. It is not of much consequence to determine or to speculate as to which one of these three causes was active. Probably, however, in view of the length of time that elapsed after the usual beginning of the heating period, there was a failure of the supply of condensing water that resulted in a pressure, reaching the bursting limit, throughout the entire high-pressure side, extending from the generator, through the rectifier and condenser, into the receiver. If this conclusion is correct, the cause of the accident was the same as in the case of the yet more disastrous explosion of a compression plant, which occurred in Newark, on Sept. 14, 1916.

Accident Could Have Been Avoided

And yet how easily this Schmidt explosion could have been avoided. A simple safeguard would have been to connect a relief valve to the generator, to blow off at the accepted pressure limit of 300 lb. and through the approved pipe connections. With such a relief valve, whether the dangerous pressure originated in the generator from a neglect to open the valve leading to the condenser or whether it originated in the condenser from a neglect to open the condenser-water valve or from a subsequent failure of the supply of condensing water, would be immaterial. In any case there would be a relief of pressure, and if the loss of ammonia was observed while in progress, the operator could stop the heating and save the residue of the charge as soon as the pressure dropped a little. With a hand-operated valve between the generator and the condenser, there should also be another relief valve connected to some part of the high-pressure side, between that valve and the expansion valve. For suppose a fire should involve the plant during the absorption period, the valve from the generator being closed. A bursting pressure might then develop in the part of the system shut off from connection with the generator relief valve.

A better construction for safeguarding both an intermittent absorption plant and also the usual continuous-acting absorption plant, equipped with an absorber, an ammonia pump and the other associated parts, is this: Provide a suitable check valve in the line from the rectifier into the condenser; make the starting of the heating of the generator and the continuance of such heating to be dependent upon the flow of an adequate supply of condensing water; graduate automatically such flow so as normally to maintain a predetermined economical head pressure; in case such head pressure is exceeded, under abnormal conditions by some such margin, as 30 or 40 lb., cause the heating of the generator automatically to be interrupted; provide, in case of fire, a relief valve connected to the top of the condenser and adapted to discharge, as has been indicated.

Intermittent Machine Not Dangerous

Since the Schmidt explosion many persons superficially acquainted with the circumstances have concluded that an intermittent absorption machine is intrinsically dangerous. With the safeguards specified, it is much safer than the compression machine. In a compressor no construction has as yet been devised successfully to prevent, under extreme conditions, the blowing off of a cylinder head. The use of a safety head merely minimizes the danger. An illuminating account of some of these accidents is recorded in Mr. Bromley's article in the issue of *Power*, dated Oct. 31, 1916. On the other hand, with an absorption machine, the rise of pressure in the generator during the heating period is so gradual that not merely can the flow of condensing water and the interruption of the operation of the machine, when necessary, be controlled by the pressure in the generator, rather than in the condenser, but also the gradualness of this rise makes impossible any accident analogous to the blowing-out of a cylinder head.

George P. Carroll.

Hartford, Conn.

Warming Up Orsat Apparatus

One is always cautioned not to place an Orsat apparatus where there are drafts, otherwise errors will occur. In our plant the most convenient place is where there is a steady draft, and in order to offset it the following is the practice:

Fifteen minutes or so before taking the CO_2 reading, the fireman fills the burette and leveling bottle with hot water so that the jacket will be warm and the gas, on being pumped in, will not have a tendency to chill.

Middletown, N. Y. Thomas M. Gray.

Inquiries of General Interest

An Alloy Fusible at 212 Deg. F.—What metal or alloy has a melting point of 212 deg. F.? R. H.

Rose's fusible alloy, consisting of 50 parts bismuth, 28.1 parts lead and 24.64 parts tin, is said to have a melting point of 212 deg. F.

Pressure That Injector Will Force Against—How much pressure will an injector force against in excess of the pressure of steam with which the instrument is supplied? L. H.

The pressure against which an injector will deliver water is usually 50 to 80 lb. per sq.in. above the pressure of dry steam supplied to the instrument. The amount of counterpressure that can be overcome depends on the form and decreases with the lift, an increase in temperature, weight of water handled and quality of steam supplied.

Boiling Point of Water and Temperature of Steam—What is the boiling point of water under a pressure of 136 lb. per sq.in. absolute, and if the temperature of steam under the same pressure is higher, what is the reason? H. M. N.

The boiling point of water under a pressure of 136 lb. per sq.in. absolute is 350.8 deg. F. The temperature of dry saturated steam at any pressure is the same as the boiling point of water under the same pressure. If steam at any pressure has a higher temperature than the boiling point of water at the same pressure, it is because it must have received additional heat, and its condition is then said to be superheated.

Forward Stroke and "Forward Running" of Engine—Which is the forward and which the return stroke of an engine, and when is an engine said to run forward or backward? T. B.

The forward stroke occurs as the piston moves from the cylinder head, and the return stroke when it moves toward the cylinder head. A horizontal engine is said to run over when the crankpin is carried over the shaft during the forward stroke and to run under when the crankpin is carried under the center of the shaft during the forward stroke. Sometimes the term "running forward" is used to designate the same thing as "running over," and "running backward" to designate "running under," but to avoid confusion the use of "forward" and "backward" should be confined to the engine's direction of rotation with reference to the direction of motion that the engine imparts to the load.

Earlier Point of Cutoff on Corliss Engine—How is earlier cutoff obtained on a Corliss engine? C. H.

The governor automatically adjusts the point of cutoff to the load. When the load is reduced, there is an increase of the speed and the higher position assumed by the governor is accompanied by its automatic adjustment of the valve gear to earlier cutoff. With a given load, if the initial pressure is increased, either by wider opening of the throttle valve or by supplying steam of higher pressure, the governor will adjust itself to earlier cutoff in the same way as when the load is reduced without change of the initial pressure. Cutoff relatively earlier in one end of the cylinder, as compared with the cutoff in the other end of the cylinder, can be obtained by adjustment of the length of the governor reach rods, but any such shortening of the cutoff in one end will cause the governor to adjust itself to later cutoff in the other end of the cylinder.

Distribution of Heat in High-Speed Gasoline Engine—In a high-speed gasoline engine, what is the distribution of the heat units contained in the fuel; what is the chemical analysis of commercial gasoline that usually is employed; and will moisture added to the fuel mixture increase the thermal efficiency? R. B. C.

The distribution of heat units of the fuel varies with the speed and power developed. Average figures for full load would be, 18 to 20 per cent. converted into mechanical energy, 30 to 35 per cent. lost to jacket water, 40 to 30 per cent. discharged in exhaust gases, and 12 to 15 per cent. of the heat is lost by conduction and radiation and unaccounted for. The chemical analysis of commercial gasoline is, carbon = 83.5 per cent. to 85 per cent., hydrogen = 15.5 per cent. to 15 per cent., and oxygen, nitrogen and sulphur 1 to 0 per cent. Water added to the fuel mixture will not increase the thermal efficiency. The claim often is made that moisture in the cylinder softens the carbon and that it is more easily blown out with the exhaust.

Formula for Compressed-Air Pipe Lines—What is the formula for the flow of compressed air through a pipe line? C. A. M.

When the drop of pressure is small relative to the initial pressure, the flow is given by a simple formula, often used for calculating pipe lines for compressed air:

$$V = k\sqrt{\frac{D^5(p_1 - p_2)}{WL}}$$

in which

V = The volume of compressed air in cubic feet per minute discharged at the final pressure;
k = A coefficient varying with the diameter of the pipe as determined by experiment;
D = Internal diameter of pipe in inches;
p_1 = Initial gage pressure, in pounds per square inch;
p_2 = Final gage pressure, in pounds per square inch;
W = The density of the air, or its weight in pounds per cubic foot at the initial pressure p_1;
L = Length of pipe in feet.

For 1-in. pipe, k = 45.3; 2 in., 52.6; 3 in., 56.5; 4 in., 58; 5 in., 59; 6 in., 59.8.

Variation in Steps of Cone Pulleys—When variable speed is obtained by belt transmission with a pair of cone or step pulleys, why is not the sum of diameters of corresponding steps made constant? F. W.

With an open belt used on the same sum of diameters, the changing angle and varying arcs of contact of the belt, when it is shifted from one pair of steps to another, would require a different length of belt. Shifting from larger and smaller diameters to equal diameters, the belt would be too long. The discrepancy becomes less with an increase of distance between centers of the cones, but for such short drives as of foot lathes and speed cones, where there is a comparatively short distance between centers and a wide ratio between the diameters, the changing belt length required must be provided for by selection of diameters more suitable to the conditions. With a crossed belt a constant sum of diameters is suitable for a uniform length of belt because the tangential portions of the belt remain of the same length, and when shifted from one pair of mating steps to another, the increase of the length of arc of contact of one step is equal to the reduction of the arc on the other.

Testing Safety of Engine Against Runaway—Before starting up a Corliss engine, how can a test be made to determine whether the engine would run away for breakage of either the main belt or the governor belt? E. W.

When the engine load is entirely removed, as by breakage of the main belt, the position of the governor that would admit sufficient steam to overcome friction and pick up speed, with a given steam pressure and throttle opening, could be known only by actual trial. Certainty of safety against runaway from this cause would require determination that neither end of the cylinder could get steam when the governor stands higher than the position corresponding to a safe speed for the engine. The corresponding speed of the governor would be known from the sizes of governor driving pulleys or gears, and if it is practicable to rotate the governor at that speed with its transmission disconnected, the corresponding position could be marked. Then with the governor blocked to that position and the eccentric reach rod unhooked, by oscillating the wristplate it could be determined whether the valve gear would permit either end of the cylinder to take steam. To test for safety against a runaway for breakage of the governor belt or governor driving gear, remove the governor starting pin and, with the governor dropped to its lowest position and the eccentric reach rod unhooked, determine whether rocking the wristplate would cause either of the steam valves to open.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

To Limit Hours in Power Plants

By the provisions of a bill introduced in the Pennsylvania Legislature it is proposed to limit the working hours of engineers and other employees in power plants in the state to 10 hours in one day and an aggregate of 56 hours a week. This measure, arranged by Representative Frederick Beyer, of Philadelphia, and drawn up by Dr. William Draper Lewis, has been placed before the House Committee on Health and Sanitation, and under its jurisdiction the hearings will be conducted at Harrisburg, being a health and safety measure devised to allow engineers and other power-plant employees reasonable freedom from operating duties during the 24-hour day. With such limitation of hours it is maintained that the number of accidents will be reduced materially, enhancing as well the general health of employees. Those favoring the adoption of the measure hold that a large number of men engaged at power plants are on duty 12 hours a day every day in the year and are responsible for the distribution of light, power, heat and refrigeration in such establishments, involving the safety and comfort of thousands of people who are dependent upon the alertness of these men and the proper performance of their many and various duties; and further, that numerous power plants are so situated that the sanitary conditions are not good, endangering the general welfare and health of employees and therefore demanding a reduction in the number of hours on watch.

The bill if enacted into a law will affect, in the state, about 300,000 men employed by electric-power companies, mining and manufacturing concerns, schools, apartment houses, office buildings and city-operated or municipal plants.

Ash Tank Explosion at Philadelphia

The recent explosion of a 50-ton concrete ash tank at the main generating station of the Philadelphia Electric Co., 28th and Christian St., killed one of the company's old employees. Another died later, either from natural causes or from the effects of gas. Two horses, which were under the tank at the time of the explosion, also were killed.

The tank was used for the storage of ashes removed from the boiler room to the tank by the vacuum process. Explosion was likely due to the accumulation of gas in the tank from the combustible in the ash, which became ignited by hot coals or sparks made by the ashes as they rushed at high velocity into the tank.

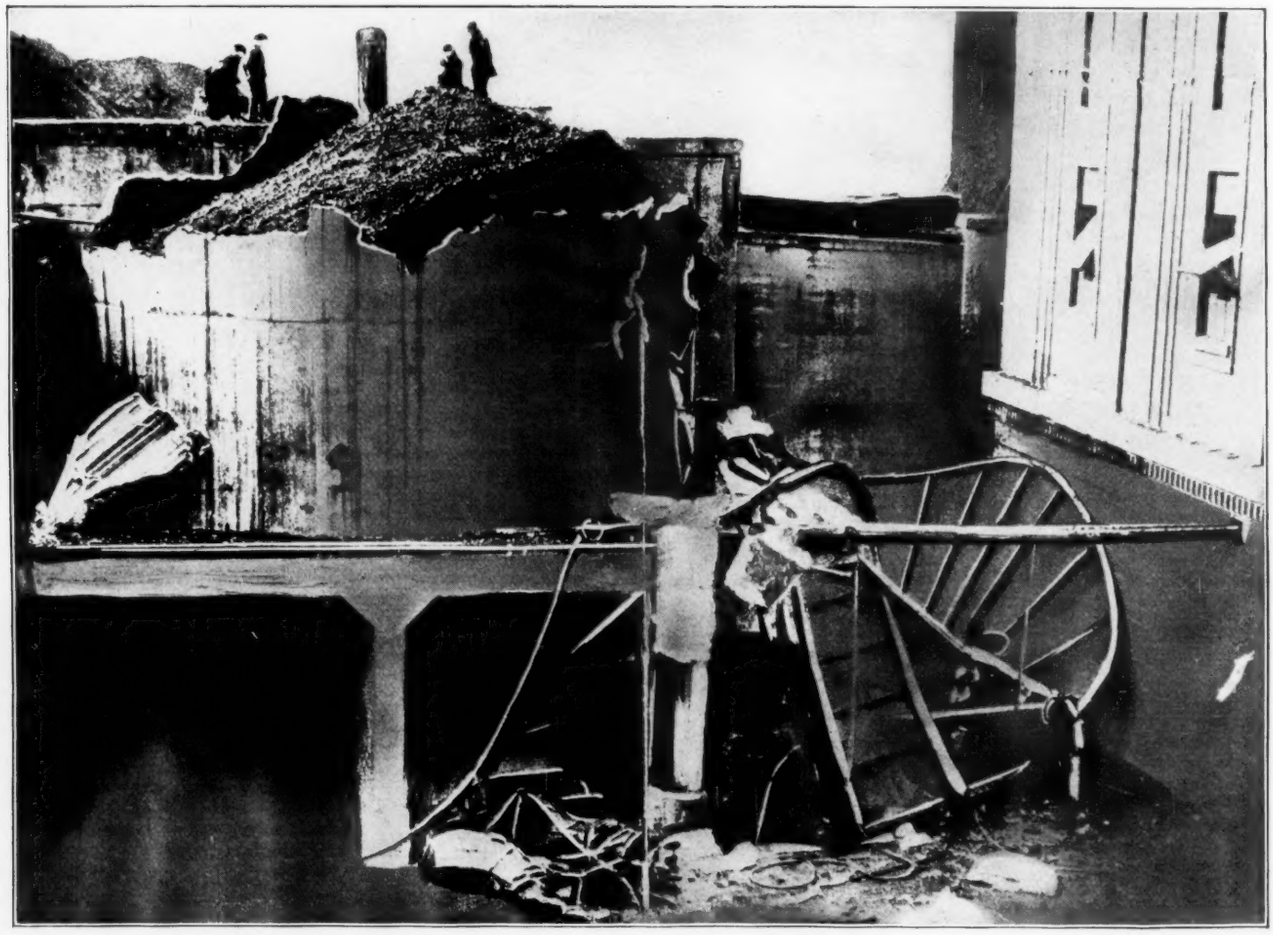
The receptacle is said to have been provided with safety devices, which ordinarily consist of covers in the top which are free to blow off, relieving the structure of harmful pressure. The photograph shows the tank after the explosion.

Central-Station Heating Discussed at Philadelphia

"District or Central-Station Steam Heating" was the subject at a joint meeting of the Philadelphia sections of the American Society of Mechanical Engineers and the American Society of Heating and Ventilating Engineers, at the Engineers' Club, Philadelphia, Mar. 27. The paper of the evening, by Walter J. Kline, sales engineer of the American District Steam Heat Co., Tonawanda, N. Y., brought forth considerable discussion.

The suggestion was made that no matter how small the plant or the waste in the form of exhaust steam it should and probably could be profitably utilized. That the business of supplying district steam heat is firmly established and yields substantial returns on a given investment with little of the element of risk or speculation is not so generally known as it should be and that a greater field is open for development than is generally realized were among the salient points brought out.

In regard to the statement and comparison of radiation loss in pipe lines, Mr. Kline advocated the "pounds per square foot per hour" basis as against that of the percentage of steam condensed, for the reason that the former is practically a constant ranging from 0.04 for a high-class job to 0.14 per square foot per hour in a poor installation, while the latter varies through an extremely wide range in any given system



EXPLODED CONCRETE STORAGE TANK OF VACUUM ASH-HANDLING SYSTEM

from "no load to full load." When the loss in pounds per square foot per hour is once determined, that constant multiplied by the total square feet and the hours per season and the cost per pound (or 1000 lb.) will give the annual fixed loss in terms of dollars and cents.

On the same basis the relative merit and the difference in first cost that can profitably be invested in insulating covering can be determined. For example, for each 0.01 lb. per hour saved, it is profitable to expend from 20 to 30c. per foot additional in the initial installation.

Meters were referred to as essential features of any service even of the smallest size—one customer; flat rates should not be considered. In the discussion one case was cited where the total steam requirement was reduced nearly one-half by the introduction of meters, eliminating thoughtless waste.

The sinking or amortization fund need not, in the speaker's opinion, exceed 2½ per cent. per annum at compound interest, to cover all repairs and a complete renewal of the installation in 30 years.

Boiler Tubes Burst at Worthington Pump Works

Two tubes of a water-tube boiler in the plant of the Henry R. Worthington Pump Co., Harrison, N. J., burst Thursday morning, Mar. 22, seriously burning one of the firemen. The steam plant was shut down for a little over half an hour because of the loss of steam through the ruptured tubes, one of which split for a length of a few feet. The injured fireman was in front of the boiler at the time—not coaling up, but in the room.

The chief engineer of the plant advised a representative of "Power" that the ruptured tubes were unusually free from scale and that the metal at the place of rupture is not thinner than the rest of the tube. The boilers do not have inward opening fire doors.

NEW PUBLICATIONS

LUBRICATING ENGINEER'S HANDBOOK. By J. R. Battle, B. S. in M. E. Published by J. B. Lippincott Co., Philadelphia, Penn., 1916. Cloth; 6 x 9 in.; 333 pages; 114 illustrations; 27 tables. Price $4.

A reference book of data, tables and general information for the use of lubricating engineers, oil salesmen, operating engineers, mill and power-plant superintendents and machinery designers, etc. The author in the preface states that the book is the result of his many years of experience, during which time he collected data and kept a notebook. These data and such descriptions and tables as have been found to be of practical value in everyday work are included in this compendium.

The work is divided into 34 chapters and treats of friction, theory of lubrication, petroleum and other lubricants and greases, lubricating oil and grease tests, oil data and miscellaneous notes, mechanical and lubricating engineering data, a brief description of the steam engine and steam turbine, their construction and operation, elementary electrical data, rolling and sliding friction and its application to bearings, the lubrication of steam cylinders, oil cups, grease cups and filters, oil houses and oil-house methods, the steam-engine indicator and its use, the lubrication of air compressors, automobiles, coal-mining machinery, baking machinery, electrical- and steam-railway equipments, passenger and freight elevators, flour-milling machinery, refrigerating machinery, internal-combustion engines, marine engines, motors and dynamos, printing machinery, pneumatic tools, rolling mills, textile machinery, steam turbines and water wheels, wiredrawing and its lubrication, the cost of lubrication and oil specifications, which are briefly touched upon.

Probably the work would appeal to the lubricating engineer more forcibly if greater space had been given to the scientific side of the lubricating problem and not so much to the descriptive. A mistake that the author seems to have made is that of attempting to treat too many subjects in the allotted space, consequently the treatment in many cases is superficial. Several subjects that have little bearing on lubrication have been included, the space taken up by which might well have been given to the lubricating subject with profit to the work as a whole. Nevertheless, the book contains a lot of valuable data and general information and will no doubt find a field of usefulness among those branches of the engineering profession it is intended to serve.

PERSONALS

L. S. Shaw is now handling the interests of the Terry Steam Turbine Co. in Detroit, Mich.

Victor L. Sanderson is now connected with the Philadelphia office of the Terry Steam Turbine Co.

Alfred H. Bartsch, for seven years advertising manager of the Bosch Magneto Co., has joined the McLain-Hadden-Simpers Co. as secretary.

Edward Walker has resigned his position as chief engineer with Spencer, Kellogg & Sons Co., Edgewater, N. J., to accept the appointment of examiner in the Engineers' License Bureau for the State of New Jersey, to fill a vacancy caused by the death of Martin J. Hickey.

Walter H. Wood, for many years associated with his brother, A. C. Wood, consulting engineer, of Philadelphia, later connected with the American Writing Paper Co., of Holyoke, Mass., as combustion engineer, and more recently superintendent of power plants of the Baltimore & Ohio R.R., has severed his connection with the latter to enter the employ of the Combustion Engineering Corporation as one of its staff of combustion experts.

W. S. Rugg, formerly district manager of the New York office of the Westinghouse Electric and Manufacturing Co., has succeeded Charles S. Cook as manager of the railway department, with headquarters at East Pittsburgh. E. D. Kilburn, formerly manager of the power department of the New York office, succeeds Mr. Rugg as district manager. E. P. Dillon, formerly assistant to the manager of the railway and lighting department at East Pittsburgh, succeeds Mr. Kilburn as manager of the power division of the New York office.

ENGINEERING AFFAIRS

The Electric Power Club will hold its spring meeting, June 11-14, at the Homestead Hotel, Hot Springs, Va.

The Steel Treating Research Club will hold the following meetings: On Friday evening, Apr. 27, L. C. Dunn will speak on "Efficient Heat Treating"; on Friday evening, May 4, Prof. J. A. Van Den Broek, of the University of Michigan, will give an illustrated talk on "The Effect of Cold Working on the Elastic Properties of Steel."

Portable Council, No. 49, Universal Craftsmen Council of Engineers, held its second annual entertainment and ball on Saturday, Mar. 24, at German Masonic Temple, East 15th St., New York City. At the close of the vaudeville entertainment, an appetizing dinner was served, after which dancing was enjoyed. The officers of the Council are: H. G. Orthman, chief; Harry Gannon, assistant chief; J. C. Koopman, recording secretary; T. Crooks, treasurer; Charles Reed, warden; F Johnson, guard; John Sanders, chaplain; J. Haldane, financial secretary.

The Boston Section of the American Society of Mechanical Engineers will hold meetings at the Engineers' Club, on the afternoon and evening of Apr. 4 and 5, to discuss central power plants, municipal electric plants and independent plants. The discussion will relate to advantages and scope of service by each kind of plant, power costs, etc. The fuel situation will likely be a matter of discussion on account of the abnormal conditions of the coal and fuel-oil markets. Probably there will be some interesting papers on municipal plants, as Massachusetts has many of these.

The State Visiting Committee of the National Association of Stationary Engineers in New Jersey ended its season's work Thursday evening, Mar. 22, with a dinner at Newark. The visiting-committee idea originated with the late Martin J. Hickey, of Jersey City, well known nationally in N. A. S. E. circles. This season's visits were made to associations in Paterson, Passaic, Jersey City, Hoboken, Newark, Elizabeth, Plainfield, Perth Amboy, Phillipsburg and Atlantic City. The Newark dinner was wholly a celebration affair. John J. Calahan was the toastmaster; Billy Murray, of Jenkins Bros., and Jack Armour, of "Power," together with an array of cabaret talent, furnished entertainment. Thomas A. Brown, president of the State Association of New Jersey, was presented with a traveling bag, the gift of those present. Past State Deputy Reddy was given a burlesque headgear symbolical of his late promotion in the engineering department of Jersey City's Board of Education.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Mar. 31, 1917	One Year Ago	Mar. 31, 1917	One Year Ago
Buckwheat	$3.40@4.40	$3.05@3.20	$6.50@6.75	$3 25@3.50
Rice	.....	2.50@2.65	5.50@5.75	2.70@2.95
Boiler	2.75@3.75	.....	4.25@4.50	.....
Barley	2.65@3.65	2.20@2.35	4.15@4.40	2.35@2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Mar. 31, 1917	One Year Ago	Mar. 31, 1917	One Year Ago
Clearfields	$4.50@5.25	$1.35@1.75	$8 00@8.75	$4.25@5.00
Cambrias and Somersets	4.90@5.50	1.55@2.00	8.50@9.00	4.60@5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $5.50@6.00, as compared with $2.80@2.85 a year ago; on cars Boston price is $10@10.50 against $5.25@6.00 a year ago.

*All-rail rate to Boston is $2 60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Mar. 31, 1917	One Year Ago	Mar. 31, 1917	One Year Ago
Buckwheat	$2.75	$2.75	$4.50@4.75	$3.50@4.00
Rice	2.20	2.25	3.50@4.00	2.65@2 75
Barley	1.95	1.75	2.50@3.00	2.30@2.40

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$6.75@7.25	$6.75@7 25	$5.00@5.25
South Forks	7.00@7.25	.....	5.25@5.50
Nanty Glo	7.00@7.25	.....	5.25@5.50
Somerset	6.75@7 00	6.75@7.00	5.00@5.25
Quehamoning	7.00@7.25	7.00@7.25	5.25@5.50

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Mar. 31, 1917	One Year Ago	Mar. 31, 1917	One Year Ago
Buckwheat	$2.50	$1.55	$3 40	$2.30
Rice	2.10	.90	3.00	1.80
Boiler	1.80	....	3.00	....
Barley	1.85	.55	2.05	1.30

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Mar. 31, 1917	One Year Ago
Slack	$3.50	$1.10@1 15
Mine-run	3.50@3.75	1.15@1.25
¾-in.	3.50@3.75	1.25@1.40

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current price per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam Lump	.....	.....	$5.00	$2.75@3.00	$2.75@3.00
Lump	$3.75@4.00	$3.75	5.00	3.00@3.25	3.25@3.50
Egg	3.75@4.00	3.75	5.00	2.75@3.00	3.00@3.25
Nut	.....	3.50@3.75	.....	2.75@3.00	2.75@3.25
No. 1 nut	3.75@4.00	.....	.....	.....	.....
No. 2 nut	3.50@3.75	.....	.....	.....	.....
No. 3 nut	3.50@3.75	.....	.....	.....	.....
No. 1 washed	3.50@3.75	.....	.....	.....	.....
No. 2 washed	3.50@3.75	.....	.....	.....	.....
Mine-run	3.00@3.25	2.75@3.25	4.50@4.75	2.00@2.25	2.00@2.25
Screenings	2.75@3.00	2.75@3.00	.....	2.00@2.25	2.00@2.25

Hocking lump, $4.00@4.25; splint lump, $4.25.

St. Louis—Price per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Mar. 31, 1917	One Year Ago	Mar. 31, 1917	One Year Ago	Mar. 31, 1917	One Year Ago
6-in. lump	$2.00@2.25	$1 35@1.50	$1.85	$1.25@1.40	$1.40@1.50	$1 00@1.15
2-in. lump	2.00	1.25@1.40	1 75	1.15@1.25	1.15@1.25	.80@1.00
Steam egg	2.00	1.20@1.40	1 75	1.15@1.25	1.15@1.25	.80@ .90
Mine-run	1 50	1.05@1.15	1.50	1.05@1.10	1.15@1.20	.80@ .90
No. 1 nut	1 75	1.20@1.50	1.75	1.15@1.25	1.35@1.50	.80@1.00
2-in. screen	1.50	.80@ .90	1.75	.75@ .90	1.10	.70@ .80
No. 5 washed	1.50	.80@ 90	1.75	.80@ .90	1.10	.75@ .85

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.
Note—No Mt. Olive district coal moving in. Higher markets north

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3.25@3.50	Carbon Hill	$2.75@3.00
Big Seam	2.50@3.00	Cahaba	3.25@3.50
Black Creek	3.25@3.50		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ala., Montgomery—The Montgomery Light and Water Power Co., 111 Dexter Ave., contemplates extending its transmission system to Wetumpka. B. C. Adams, Mgr.

Ark., Gillham—B. & A. Mining Co. will construct a hydro-electric plant.

Ark., Mansfield—Cola Dist. Power Co. will improve its electric plants in Mansfield, Greenwood, Huntington and Hartford and will install $75,000 worth of machinery.

Ark., Paris—City has retained Winters & Dove, Ft. Smith, to make surveys for installing an electric-light plant.

Ark., Pine Bluff—The Pine Bluff Co. contemplates extending its high-tension transmission lines to Stuttgart, England and other towns and cities.

B. C., Nelson—City plans an addition to third unit of the power plant. W. E. Wasson, City Clk.

Calif., Oakdale—The Sierra & San Francisco Power Co., 58 Sutler St., San Francisco, will construct a substation. Estimated cost, $10,000. L. C. Helfridi, Pur. Agt.

Calif., Oroville—The Great Western Power Co., 14 Sansome St., San Francisco, will construct a power plant, including a concrete-lined canal 15 mi. long, 25 ft. wide, 14 ft. deep. The water will be obtained from the north fork of the Feather River near the mouth of the west branch. The plant will develop 75,000 kv.a. Estimated cost, $6,000,000.

Calif., San Francisco—The Pacific Gas and Electric Co., 445 Sutler St., will construct a substation at Lexington Ave. and 19th St. Estimated cost, $38,000. J. Brittin, Vice Pres. and Gen. Mgr.

Ga., Davidsboro—The city has retained W. M. Crook, Engr., Grand Bldg., Macon, to prepare plans for an electric-light plant.

Ill., Chicago—The Illinois Northern Utilities Co. will construct a 75 x 100-ft. steam power plant. Estimated cost, $300,000. E. D. Alexander, Vice Pres.

Ill., Chicago—The Turner Manufacturing Co., 1444 South Sangamon St., is having plans prepared for a 2- and 3-story power house and dry kiln on Ogden Ave. between Keeler and Kedvale Ave. Estimated cost, $150,000. A. S. Alschuler, 20 East Jackson Blvd., Arch.

Ind., Griffin—City voted bonds to install an electric-light plant.

Ind., Lafayette—City will install an electric-light plant. H. B. Overesch, City Engr.

Kan., Bison—City will install an electric-light plant and transmission line to La Crosse to obtain electricity to operate the system.

Kan., Cherryvale—The Cherryvale Electric Co. is receiving bids for a 1-story, 34 x 50-ft. electric generator station. Estimated cost, $7000. F. F. Fletcher, 112½ East Myrtle St., Independence, Engr.

Kan., Irving—City plans to hold an election to vote on $7000 bonds to install a distribution and lighting system and transmission line to Blue Rapids.

La., Kenner—City will receive bids Apr. 9 for an electric-light and power plant.

Mass., Salem—The Salem Electric Lighting Co., 72 Washington St., will construct a 2-story, 60 x 114-ft. brick and reinforced-concrete plant on Peabody St. Estimated cost, $50,000.

Minn., Hibbing—City retained Tyrie & Chapman, Auditorium Bldg., Minneapolis, to prepare plans for a 1-story power house. Estimated cost, $200,000. D. D. Haley, City Clk.

Mo., St. Louis—Bids will soon be received for a 2-story, 40 x 50-ft. boiler house for the Sisters of Mercy, 307 South Euclid Ave. Barnett, Haynes & Barnett, Century Bldg., Arch.

Neb., Lithfield—The city has voted $7000 bonds to install an electric-lighting system.

Nev., Reno—The Navada Valleys Power Co., 410 1st National Bank Bldg., Oakland, Calif., will construct a generating plant to develop 2500 hp. J. G. Brown, Oakland, Vice Pres. and Gen. Mgr.

N. Y., New York—(Borough of Manhattan)—The Eagle Pencil Co., 710 East 14th St., has had plans prepared for an alteration to its 1-story brick boiler room at 703-731 William St.

N. Y., Whitney Point—The Union Electric Co. will install a concrete dam during the summer and will change the system from 133 to 60 cycles. D. O'Connell, Pres. and Mgr.

Ohio, Bluffton—City voted $35,000 bonds to improve the electric-light plant.

Ohio, Cleveland—The Cleveland Electric Illuminating Co. has had plans prepared for a 2-story, 50 x 69-ft. substation at 817 East 103rd St. Estimated cost, $35,000. W. H. Hartman, 711 Cuyahoga Bldg., Pur. Agt.

Ohio, Wilmington—The Wilmington Gas, Light and Coke Co. is having plans prepared for an addition to its gas plant. Estimated cost, $25,000.

Okla., Gate—City has issued $7000 to install an electric-lighting system.

Okla., Hendrick—City will install an electric-lighting system.

Ont., Aylmer—City plans to install a hydro-electric and power distributing system. E. A. Coughill, Chn. Light Comn.

Penn., Altoona—The Penn Central Light and Power Co. will make improvements to its system to cost $120,000. H. A. Crownover, 1412 11th Ave., Pur. Agt.

Pa., Bloomsburg—The Electric Bond and Share Co., 71 Broadway, New York, which recently acquired the plant of the Northern Central Co., will make additions and improvements to the system, including a power plant for mill and industrial works operation.

Prices—Materials and Supplies

ELECTRICAL SUPPLIES

Knife Switches—Following are net prices each in cities named for knife switches mounted on slate base, front connected, punched clip type 250 volts:

	30 Amp. New York	30 Amp. Chicago	30 Amp. St. Louis	60 Amp. New York	60 Amp. Chicago	60 Amp. St. Louis
Double pole, single throw, fuseless	$0.91	$0.58	$0.49	$1.04	$1.04	$0.88
Double pole, single throw, fused..	.91	.90	.76	1.53	1.53	1.30
Double pole, double throw, fuseless	1.45	.99	.84	1.70	1.70	1.44
Double pole, double throw, fused	1.87	1.91	1.50	2.89	2.89	2.45
Triple pole, single throw, fuseless	1.36	.87	1.15	1.57	1.57	1.32
Triple pole, single throw, fused..	1.36	1.36	1.15	2.30	2.30	1.94
Triple pole, double throw, fuseless	2.27	1.53	1.92	2.64	2.64	2.23
Triple pole, double throw, fused..	3.10	2.99	2.53	4.63	4.63	3.92

	100 Amp. New York	100 Amp. Chicago	100 Amp. St. Louis	200 Amp. New York	200 Amp. Chicago	200 Amp. St. Louis
Double pole single throw, fuseless	$2.13	$2.13	$1.80	$3.83	$3.83	$3.24
Double pole single throw, fused..	3.12	3.11	2.64	5.75	5.75	4.87
Double pole, double throw, fuseless	3.83	3.83	3.24	6.38	6.38	5.40
Double pole, double throw, fused.	6.29	6.29	5.33	11.05	11.05	9.36
Triple pole, single throw, fuseless	3.20	3.20	2.71	5.75	5.75	4.87
Triple pole, single throw, fused..	4.68	4.68	3.96	8.62	8.62	7.30
Triple pole, double throw, fuseless	5.87	5.87	4.97	9.86	9.86	8.35
Triple pole, double throw, fused..	10.07	10.07	8.52	17.68	17.68	14.98

Lots $25 and more, list.

Fuses—Following are net prices in cities named in standard packages:

ENCLOSED FUSES, EACH

	New York	Chicago	St. Louis	Package
30	$0.13	$0.18	$0.09	1.00
31-60	.18	.25	.12	1.00
61-100	.46	.43	.32	1.50
110-200	1.02	.70	.70	.25
225-400	1.84	1.17	1.26	.25

FUSE PLUGS, PER 100

	New York	Chicago	St. Louis
30	$4.20	$6.50	$3.90

Standard package fuse plugs, 500; 100, less than package, 5c. each.

Sockets—Following are net prices in cents each in cities named in standard packages

	⅛-In. Cap Package	⅛-In. Cap Key	⅛-In. Cap Keyless	⅛-In. Cap Pull Chain	⅜-In. Cap Package	⅜-In. Cap Key	⅜-In. Cap Keyless	⅜-In. Cap Pull Chain
New York	500	23.10	21.00	42.00	250	27.30	25.20	46.20
Chicago	500	31.50	28.50	57.00	250	37.00	39.00	62.50
St. Louis	500	21.78	19.80	39.60	250	25.74	23.76	43.56

	Pendant Cap ⅛ In. Package	Key	Keyless	Pull Chain	Less Than Package in ⅛ and More	Pendant and Key	Pendant and Keyless	Pendant and Pull Chain
New York	250	23.10	21.00	42.00	27.00	24.00	48.00	
Chicago	250	31.50	31.50	57.00	35.00	31.00	44.00	
St. Louis	250	21.78	19.80	39.60	26.40	24.00	48.00	

Cut Outs—Following are net prices each in cities named for standard package quantities:

EDISON PLUG 0-30

	Package	New York	Package	Chicago	St. Louis
D. P. M. L.	50	$0.18	150	$0.24	$0.17
T. P. M. L.	50	.26	100	.35	.24
D. P. S. B.	50	.19	100	.26	.18
T. P. S. B.	50	.32	75	.50	.30
D. P. D. B.	25	.37	100	.50	.34
T. P. D. B.	25	.54	50	.72	.50
3- to 2-wire D. B.	25	.38	100	.51	.35

CARTRIDGE FUSE

	0-30 New York	0-30 Chicago	0-30 St. Louis	31-60 New York	31-60 Chicago	31-60 St. Louis	61-100 New York	61-100 Chicago	61-100 St. Louis
D. P. M. L.	$0.33	$0.40	$0.30	$0.84	$1.01	$0.77	$1.68	$2.02	$1.48
T. P. M. L.	.48	.58	.44	1.20	1.44	1.10	2.40	2.88	2.21
D. P. S. B.	.42	.51	.39	1.05	1.26	.96	...	...	...
T. P. S. B.	.81	.97	.74	1.80	2.16	1.65	...	...	...
D. P. D. B.	.78	.94	.72	2.10	2.52	1.93	...	...	...
T. P. D. B.	1.35	1.62	1.24	3.60	4.32	3.30	...	...	...
3- to 2-wire D. B.	.90	1.08	.83	2.52	3.03	2.31	...	...	...

Separable Attachment Plugs—Following are prices each in cities named:

	Package	Porcelain	Composition	Package	Side Outlet Current Taps
New York	250	$0.21	$0.28	50	$0.35
Chicago	450	.27	.36	50	.45
St. Louis	250	.16	.17	50	.33

Cord—Following are prices each in cities named, in cents per foot:

	Coil, Foot	New York	Chicago	St. Louis
No. 18 cotton, parallel	250	2.83	4.29	2.65
No. 16 cotton, parallel	250	3.65	5.85	3.36
No. 18 cotton, reinforced	250	4.07	4.47	3.05
No. 16 cotton, reinforced	250	4.86	5.55	4.22
No. 18 canvasite	250	3.17	3.58	4.00
No. 16 canvasite	250	3.88	4.45	4.98

	Coil, Foot	New York	Chicago	St. Louis
¼-in. loom	250	3.00	3.00	2.20
⅜-in. loom	250	4.50	.450	3.96
½-in. loom	200	6.00	6.00	5.28
⅝-in. loom	200	7.50	7.50	6.06
¾-in. loom	150	9.00	9.00	7.92
1-in. loom	100	12.50	12.50	11.00
1¼-in. loom	100	16.50	16.50	14.52
1½-in. loom	100	20.00	20.00	17.60

Copper Wire—Following are prices in cents per foot in cities named for rubber-covered wire in standard quantities of 1000 ft.:

No.	New York Single Braid	New York Double Braid	New York Duplex	Cleveland Single Braid	Cleveland Double Braid	Cleveland Duplex
14	13.50	11.36	26.00	11.50	14.00	33.00
12	17.70	19.32	38.04	17.00	18.00	38.20
10	24.30	26.76	53.04	....	....	....
8	34.50	37.28	74.16	....	....	....
6	61.24	64.84	....	....	....	....
5	72.72	76.72	....	....	....	....
4	78.96	92.64	....	....	....	....
3	107.20	112.00	....	....	....	....
2	131.60	136.80	....	....	....	....
1	171.20	178.00	....	....	....	....
0	215.00	215.60	....	224.00	224.00	224.00
00	264.00	264.00	....	273.60	273.60	273.60
000	325.20	325.20	....	336.00	336.00	336.00
0000	396.80	396.80	....	408.80	408.80	408.80

No.	Chicago Single Braid	Chicago Double Braid	Chicago Duplex	St. Louis Single Braid	St. Louis Double Braid	St. Louis Duplex
14	14.00	16.00	28.00	12.00	16.50	29.00
12	25.62	29.22	58.59	25.74	29.34	52.96
10	32.61	36.46	66.50	33.44	37.29	67.20
8	47.25	51.65	93.40	47.68	52.08	94.20
6	68.5¢	73.00	....	77.80	82.30	148.14
5	82.50	87.50	....	92.45	97.45	175.41
4	99.60	105.10	....	101.02	105.97	201.36
3	115.65	120.95	....	122.85	128.25	....
2	136.35	142.20	....	150.75	156.60	....
1	178.20	185.80	....	195.75	203.40	....
0	244.35	244.35	....	234.27	234.47	....
00	301.95	301.95	....	288.13	288.13	....
000	368.10	368.10	....	353.97	353.97	....
0000	449.55	449.55	....	432.20	432.20	....

Conduit, Elbows and Couplings—Following are net prices in cents per ft. in New York in 1000-ft. lots:

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft

In.	Rigid Black Enam. Conduit	Conduit Elbows	Conduit Couplings	In.	Flexible Conduit—Conduit	Flexible Conduit—Couplings
½	5.27	12.92	4.76	½	6.50	6.47
¾	6.90	17.00	6.80	¾	8.45	8.40
1	10.20	25.16	8.84	1	13.65	11.20
1¼	13.80	32.85	12.41	1¼	16.90	15.40
1½	16.50	43.80	15.33	1½	22.75	21.00
2	22.20	80.30	20.44	2	29.25	30.10
2½	35.10	131.40	29.20	2½	33.80	52.50

Locknuts and Bushings—Following are net prices in New York in standard packages, which are: ½ in., 1,000; ¾ to 1¼ in., 100; 1½ to 2 in., 50:

In.	Locknuts Per 100	Bushings Per 100	Flexible Conduit Box Connections Per 100
½	$1.02	$1.68	$5.62
¾	1.75	4.00	7.12
1	3.00	6.15	10.50
1¼	5.00	8.20	15.00
1½	7.50	10.25	22 50
2	10.00	16.40	30 00
2½	12.30	24.60	67.50

Armored Cables and Box Connectors—Following are net prices in New York per 1,000 ft. cable and standard package of 100 box connectors in single and double strip:

Wire Gage	Twin Conductor Cable	Twin Conductor Connectors	Three Conductor Cable	Three Conductor Connectors
14	$75.00	$4.50	$106.26	$4.50
12	103.95	4.50	130.90	4.50
10	142.45	4.50	180.95	4.50
8	180.95	4.50	250.25	5.70
6	284.90	5.70	363.44	8.10
4	442.75	8.40	.....	....

Lamps—Below are present quotations in less than standard package quantities:

Mazda B Watts	Straight-Side Bulbs Plain	Straight-Side Bulbs Frosted	No. in Package	Mazda C Watts	Pear-Shape Bulbs Clear	Pear-Shape Bulbs Frosted	No. in Package
10	$0.27	$0.30	100	75	$0.65	$0.70	..
15	.27	.30	100	100	1.00	1.05	24
25	.27	.30	100	300	3.00	3.10	24
40	.27	.30	100	500	4.50	4.65	12
50	.28	.31	100	750	6.00	6.25	8
60	.36	.40	100	1,000	7.00	7.25	8

Standard package quantities are 10% from above prices. Yearly contracts ranging from $150 up allow a discount of 17½% from list.

MISCELLANEOUS

Hose—

	Fire 50-Ft. Lengths
Underwriters', 2½-in.	55@60c. per ft.
Common, 2½-in.	60% from list

	Air First Grade	Second Grade	Third Grade
¾-in., per ft.	$0.45	$0.25	$0.18

Steam—Discounts from list

First grade..... 33⅓% Second grade..... 40% Third grade..... 50%

Rubber Belting—The following discounts from list apply to transmission rubber and duck belting:

Competition ..... 60% Best grade 30%
Standard 50%

Leather Belting—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40—5%	35—5%
St. Louis	40—5%	40%
Chicago	45—5%	35—10%

Packing—Below are prices each in cities named per pound:

Asbestos

		New York	Chicago
Valve and Stuffing Box	Twisted plain, 25-lb. cartons	$0.65@0.70	$0.80
	Twisted graphite, 25-lb. cartons	.80	.90
	Braided plain, 25-lb. cartons	.90	1.00
	Braided graphite, 25-lb. cartons	1.00	1.10

Asbestos wick in balls, ¼-, ½-, 1-, 25- and 50-lb. cartons, $0.65@0.70, New York; $0.80, Chicago.

Rubber asbestos, compressed sheet, medium grade about $0.80, New York, $0.93, Chicago.

Steam

Following in 25- and 50-lb. cartons:

First grade ..... $0.75 Second grade $0.50

Rubber and Duck

Higher grade ..... $0.40 Cold water $0.25

Piston

Asbestos, duck and rubber... $1.25 Rubber and duck..... $0.90
Flax first grade..... .85

Pipe and Boiler Covering—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard Thickness Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in	.30
3-in	.45	1½-in.	.45
4-in.	.60	2 -in.	.60
6-in.	.80	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05
12-in.	1.85	4 -in.	1.20
14-in.	2.10		

85% magnesia high pressure..... 20% off

Air cells for low-pressure heating and return lines { 4-ply..... 65% off; 3-ply..... 67% off; 2-ply..... 70% off

Greases—Prices are as follows in the following cities in cents per pound for bbl lots:

	New York	Chicago	St. Louis
Cup	5@7	6	4
Fiber or sponge	5@7	6¼	5
Transmission	5@7	6¼	5
Axle	3@4	3½	3
Gear	4@5	5	3
Car journal (S. & F.)	6½	4½	9½

Cotton Waste—The following prices are in cents per pound:

	New York			
	Mar. 28, 1917	One Year Ago	Cleveland	Chicago
White	13.00@15.00	11.00@13.00	12.50@14.00	13.00@15.00
Colored Mixed	10.00@12.00	8.00@10.00	8.50@12.00	10.00@12.00

Wiping Cloths—In Cleveland the jobbers' price per 1,000 is as follows.

13¼x13¼ ..... $35.00 13¼x20½ $45.00

In Chicago they sell at $30@33 per 1,000.

Manila Rope—Price per lb. in 1,200-ft. coils, New York:

	Ft. per Lb.			Ft. per Lb.	
⅞-in.	8	$0.24½	1 -in.	3 ft. 6 in.	$0.24½
¾-in.	6	.24½	1⅛-in.	2 ft. 10 in.	.24½
⅞-in.	4 ft. 6 in.	.24½	1¼-in.	2 ft. 4 in.	.24½

Sizes smaller than ⅝-in. from ½ to 2c. extra per lb Extra charge of 1c. per lb. for less than 600 ft.

Ammonia—Below are New York prices per lb.:

26° U.S.P. carboys of 100 lb..... 6¼c.
26° U.S.P. drums of 1,000 lb..... 5½c.

Linseed Oil—These prices are per gallon:

	New York		Cleveland		Chicago	
	Mar. 27, 1917	Six Months Ago	Mar. 27, 1917	Six Months Ago	Mar. 27, 1917	Six Months Ago
Raw in barrels	$1.02	$0.73	$1.10	$0.75	$1.03	$0.74
5-gal. cans	1.12	.83	1.20	.85	1.13	.84

Boiled, 1c. per gal. additional.

White and Red Lead, in cents per pound, sell as follows:

	Red				White	
	Dry Mar. 27, 1917	In Oil Mar. 27, 1917	Dry 6 Months Ago	In Oil 6 Months Ago	Dry and In Oil Mar. 27, 1917	Dry and In Oil 6 Months Ago
100-lb. keg	11.25	11.50	10.50	11.00	11.00	10.50
25- and 50-lb. kegs	11.50	11.75	10.75	11.25	11.25	10.75
12½-lb. keg	11.75	12.00	11.00	11.50	11.50	11.00
1- to 5-lb. cans	13.25	13.50	12.50	12.50	13.00	12.50

Fire Brick—Quotations on the different kinds in the cities named are as follows f.o.b. works:

	New York	Joliet, Ill.	St. Louis
Silica brick, per 1,000	$40.00@50.00	$50.50	$40.00
Fire clay brick, per 1,000	35.00@45.00	35.00@50.00	40.00
Fire clay brick, per 1,000, No. 1	....	....	28.00@30.00
Magnesite brick, per net ton	140.00@145.00	135.00	....
Chrome brick per net ton	....	135.00	....
Deadburned magnesite brick, per net ton	85.00@90.00	85.00	....
Special furnace chrome brick, per net ton	60.00@70.00	60.00@70.00	....

Standard size, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per ton.

Fuel Oil—Price in cents per gal., in the following cities in bbl. lots:

	New York	Chicago	St. Louis
Domestic light, 22-26 Baumé	6@6½	4½	8½
Mexican heavy, 12-14 Baumé	5@5½	5⅛	...

Chicago f.o.b.)

Poles—The prices on Western red cedar poles, effective Dec. 21, 1916:

	New York	Chicago	St. Louis	Denver
6 in. by 30 ft	$5.24	$4.59	$4.59	$3.97
7 in. by 30 ft	6.90	6.10	6.10	5.30
7 in. by 35 ft	9.70	8 60	8.60	7.55
8 in. by 35 ft	11.20	9.90	9.90	8.65
7 in. by 40 ft	11.35	10.00	10 00	8.75
8 in. by 40 ft	12.75	11.15	11.15	9.65
8 in. by 45 ft	15 70	13.70	13.70	11.80
8 in. by 50 ft	18.35	15.95	15.95	13.65

Portland Cement—These prices are for barrels in carload lots including bags:

	Mar. 29, 1917	One Month Ago	One Year Ago
New York	$1.97	$1 97	$1.27
Jersey City	1.85	1.85	1.21
Boston	2.17	2.17	1.47
Chicago	2.16	1.96	1.36
Pittsburgh	2.16	2.06	1.36
Cleveland	2.29	2.19	1.50
Detroit	2.25	2.15	1.45
Indianapolis	2.29	2.19	1.49
Toledo	2.29	2.15	1.49
Milwaukee	2.28	2.08	1.48
Minneapolis	2.43	2.23	1.63
Duluth	2.41	2.21	1.56
Peoria	2.28	2.08	1.44
Cedar Rapids	2.39	2.19	1.55
Davenport	2.34	2.14	1.45
St. Louis	1.95	1 95	1.40
San Francisco	2.30	2.30	1.90

Pipe—The following discounts are for carload lots f.o.b. Pittsburgh, basing card in effect Mar. 5, 1917:

BUTT WELD

Steel			Iron		
Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼ and ⅜	53%	26½%	¾ to 1½	50%	36%
½	57%	42½%			
¾ to 3	60%	46½%			

LAP WELD

2	51%	38½%	1¼	36%	21%
2½ to 6	54%	41½%	1½	42%	34%
			2	43%	29%
			2½ to 4	45%	32%
			4½ to 6	45%	32%

BUTT WELD. EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	49%	31½%	¾ to 1½	45%	28%
½	54%	41½%			
¾ to 1½	58%	45½%			
2 to 3	59%	46½%			

LAP WELD. EXTRA STRONG PLAIN ENDS

2	43%	33½%	1¼	38%	23%
2½ to 4	45%	35½%	1½	43%	29%
4½ to 6	44%	34½%	2	45%	32%
			2¼ to 4	47%	35%
			4½ to 6	46%	34%

From New York stock the following discounts hold:

	New York	
	Black	Galvanized
¾ to 3 in. steel butt welded	51%	35%
3½ to 6 in. steel lap welded	44%	26%

In Chicago and Cleveland the following discounts hold:

	Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized
¾ to 3 in. steel butt welded	55%	41%	56.8%	42.8%
3½ to 6 in. steel lap welded	51%	38%	52.8%	39.8%

Malleable fittings, Class B and C, from New York stock sell at 15 and 5% from list price Cast iron, standard sizes, 42½ and 5%.

Boiler Tubes—Discounts on less than carloads from Pittsburgh, freight to be added, effective from Nov. 1, 1916, except 3 to 4½ in. steel from Nov. 20, are as follows:

Lap Welded Steel		Standard Charcoal Iron	
1½ in.	31%	1½ in.	23%
1¾ and 2 in.	43%	1¾ and 2 in.	35%
2¼ in.	40%	2¼ in.	32%
2½ and 2¾ in.	46%	2½ and 2¾ in.	38%
3 and 3¼ in.	46%	3 and 3¼ in.	43%
3½ to 4½ in.	46%	3½ to 4½ in.	44%
5 and 6 in.	45%	5 and 6 in.	37%
7 to 13 in.	42%	7 to 13 in.	34%

Locomotive and steamship special charcoal grades bring higher prices. 1¾ in., over 18 ft. and not exceeding 22 ft., 10% net extra. 2 in. and larger, over 22 ft., 10% net extra.

Cast-Iron Pipe—The following are prices per net ton for carload lots:

	New York					
	Dec. 4, 1916	One Month Ago	Birmingham	Chicago	St. Louis	San Francisco
4 in.	$48.50	$44.50	$42.00	$48.15	$47.00	$54 00
6 in. and over	45.15	41.50	39.00	45.15	44.00	51.00

Gas pipe and 16-ft. lengths are $1 per ton extra.

Cold Drawn Steel Shafting—From warehouse to consumers requiring fair-size lots, the following quotations hold:

	Jan. 30, 1917	Six Months Ago
New York	List plus 10%	List plus 20%
Cleveland	List plus 10%	List plus 20%
Chicago	List plus 5%	List price